

PROSPECTS FOR HARDWOOD PULP MANUFACTURE IN ILLINOIS

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BULLETIN 718

**UNIVERSITY OF ILLINOIS COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION**

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ILLINOIS RANKS FIFTH among states in the value of timber-based activities, their value in 1958 being about 1.4 billion dollars, or 5.5 percent of the total for the United States. Of the 3.4 million people employed in timber-based activities in the United States, about 157,000, or 4 percent, are employed in Illinois. Only New York, California, and Pennsylvania outrank Illinois in the value of timber-based activities and number of employees in these activities.

No official estimate of Illinois wood consumption has been made recently, but 1947 requirements were estimated to be between 1.5 and 2.0 billion board feet annually. Roughly three-fourths of this volume was in softwood species, almost all of which had to be imported from surrounding states since Illinois forests principally contain hardwood species. However, in 1947 the state was also importing about 75 percent of its hardwood requirements, despite the abundance of hardwood timber in the forested areas of west-central and southern Illinois.

Without doubt wood requirements have risen markedly since 1947. It is likely that present-day requirements amount to between 2 and 3 billion board feet annually. There are indications that production of timber products in Illinois has also risen, although most of the state's requirements are still being met from outside sources. Hardwood lumber, which is by far the most important primary forest product in the state, has increased from 100 million board feet in 1947, to 122 million board feet in 1961. Production of veneer logs has increased from 11.3 million board feet in 1947, to 17.4 million board feet in 1961. In the same period, stave bolt production increased from 11.8 to 27.4 million board feet.

Production and consumption of hardwood pulpwood have expanded greatly in Illinois in recent years. In 1947, the state produced 39,000 standard cords. By 1964, production had risen to more than 100,000 cords, of which about 10,000 cords were softwood. Illinois ranks second to Ohio in pulpwood production among the central states.¹ Despite increased production, the Central States have had to import some pulpwood, principally soft hardwoods and softwood species from Wisconsin.

¹ Included in the central states are Ohio, Illinois, Indiana, Iowa, Kentucky, and Missouri. Data from forest survey timber resource tables, of the U.S. Forest Service, 1962.

As far as softwood timber requirements are concerned, Illinois will probably always be heavily dependent on imports. However, Illinois forests can and should make a far greater contribution to the state's hardwood needs.

It is estimated that the volume of annual growth of native hardwood timber is about 2.8 times the volume cut. There is no simple explanation for this imbalance. Undoubtedly the preponderance of low-quality timber contributes to the situation. Considering the entire state and all hardwood species, only 5 percent of the state's saw-timber volume qualifies as Log Grade 1 material; about 5 percent qualifies as Grade 2; and fully 90 percent qualifies no higher than Grade 3. Generally speaking, Illinois secondary wood-using industries¹ require the better grades of lumber and other primary forest products. Where these cannot be supplied from native stock, they must be and are imported from other regions.

Past practices of high grading (removal of only the best trees) and lack of intensive forest management on the private forest holdings of the state account, in part, for poor timber quality, the resulting high growth-cut relationship, and lack of markets. In turn, lack of markets discourages more intensive forest management on many forest holdings. Other reasons for the low level of forest management include the small size of many forest holdings, lack of knowledge on the part of woodland owners as to possible returns from timber, lack of capital for use in woodland improvement, instability of tenure on many forest holdings, and opportunities for greater returns from alternative endeavors. Also, there is considerable evidence to show that forest owner attitudes toward management and use of woodland holdings are varied and complicated. It is quite likely that these attitudes frequently are derived from a complex of variables which include not only the woodland characteristics, but the characteristics of the owner himself; such factors as income, age, state of health, educational level, general background, and personality may all be involved.

Despite the problems mentioned above, it appears that considerable improvement in forest management on many woodland holdings could be effected if more markets for low-quality hardwoods could be developed. If a market were available for this purpose, some of the immediate income might be spent on woodland improvements. Even more important, however, the removal of low-quality material from timber stands, together with improved sawmilling and marketing practices,

¹Secondary wood-using industries include furniture manufacturers, producers of cooperage, pallets, boxes and crates, toys, signs, fixtures, and many other products of which wood is an important component.

would in time make possible the production and marketing of higher-quality material needed in the state's secondary wood-using industries and presently being supplied from outside sources. That is, once low-quality trees are removed, growth which is now being made on trees of poor form and quality could be transferred to the better trees.

The most promising potential market for lower-quality hardwood timber is pulpwood. A pulp and paper industry is already established in the state. There are 8 wood-using pulp plants with a total daily capacity of 848 tons presently in operation. In 1964 these plants used almost 85 thousand cords of pulpwood, 99 percent of which was hardwood. Indications are that markets for hardwood pulpwood will continue to expand rapidly throughout the country. Recent projections show a doubling of consumption of hardwood pulpwood by 1980. The principal objective of this study is to assess the feasibility of hardwood pulpwood market expansion in Illinois in the light of expected increased demands for pulp and paper products nationally.

Objectives and Scope of the Study

Evaluation of potential pulp and paper manufacturing sites is obviously a difficult and complex undertaking. Although certain important factors which influence the establishment of mills will be examined, the selection of specific mill sites lies beyond the scope of this study. In most cases, selection of mill sites requires the careful evaluation of specific economic and engineering details applicable to each individual situation.

Major emphasis in this report is on examining (1) the present structure and functioning of the pulp and paper industry in Illinois, (2) the prospects for increased consumption of those pulp and paper products which can be made from hardwood pulpwood of the kinds to be found on Illinois woodlands, (3) the physical adequacy of the several resources and required services needed to support an expanded pulp and paper industry in the state, (4) an evaluation of the major procurement and distribution costs which would be involved in pulp and paper expansion in Illinois, (5) an estimate of the prospective competitive position of an expanded pulp and paper industry in Illinois relative to pulp and paper industries in other important producing areas, and (6) a brief description of those areas in Illinois where expansion in pulp and paper manufacturing and pulpwood marketing appear feasible.

This report represents a joint effort by forest technicians with experience and knowledge in forest resource analysis, timber management, forest product marketing, and economic analysis. Pertinent

published information on these subjects and professional experience in other relevant areas were assembled, supplemented by special field surveys, and analyzed to achieve the stated objectives.

Evaluations of pulpwood marketing potentials apply to existing native timber, including coniferous plantations. No attempt is made to evaluate the economic aspects of establishing new coniferous or hardwood stands for pulpwood production in the light of study results. Furthermore, although marketing and forest management problems are interrelated, this report does not consider the economic implication of other capital intensive forest management alternatives which may appear, depending upon pulpwood marketing possibilities.

Present Status of the Pulp and Paper Industry and Pulpwood Marketing in Illinois

Organization of the pulp and paper industry

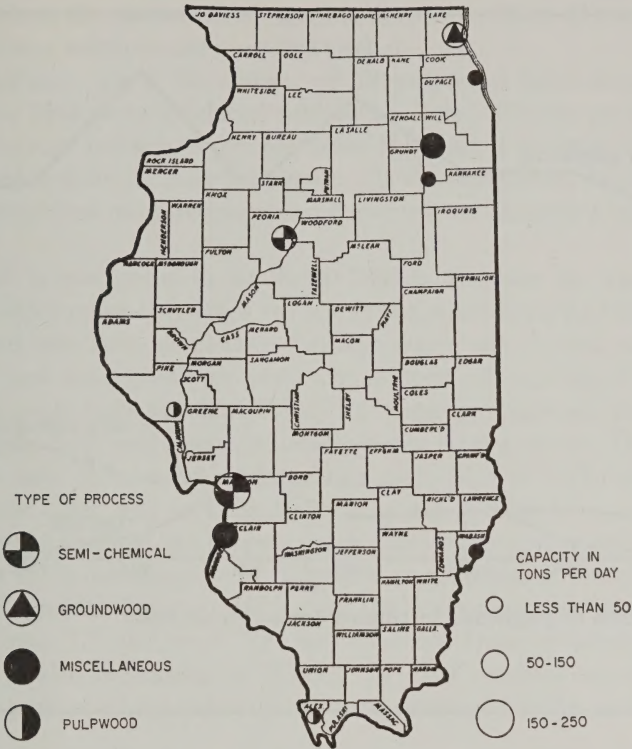
Illinois has 8 plants which use wood in the manufacture of pulp and fiber products. These plants have a total daily capacity of 848 tons (Fig. 1). Only Ohio, with 1,100 tons, outranks Illinois among the central states. These two states together account for over 75 percent of total daily capacity in the central states.

On a national basis, woodpulp is the most important fibrous raw material used in the manufacture of paper and paperboard products. However, on a nationwide basis, the mills in the central states use nearly three times as much of other fibrous materials as wood pulp; most of this material is waste paper. In 1958 in Illinois, almost seven times as much waste paper as wood pulp was used, primarily in the manufacture of roofing felts and building and insulating boards.¹ There are 37 paper and paperboard mills operating in Illinois. Of these, only 7 make paper; the others manufacture paperboard, building paper, and fiberboard products.

The trend in recent years has been in the direction of greater use of wood pulp because of increased cost of collecting and processing waste paper and other fibrous materials. Increased production of paper and paperboard products in Illinois will most likely involve greater use of pulpwood as the basic raw material.

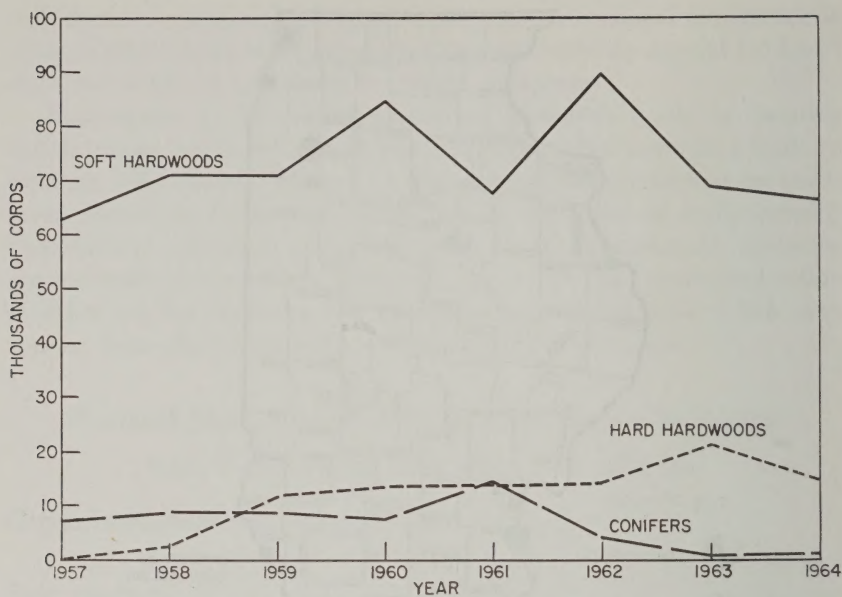
Over 60 percent of the Illinois pulping capacity is devoted to the manufacture of roofing felts for asphalt roof and siding shingles,

¹ Manthy, Robert S., and James, L. M., *Marketing Pulpwood in Selected Areas of the North Central Region*, Michigan Agr. Exp. Sta. Res. Bul. 6, North Central Reg. Pub. 156, Michigan, 1964.



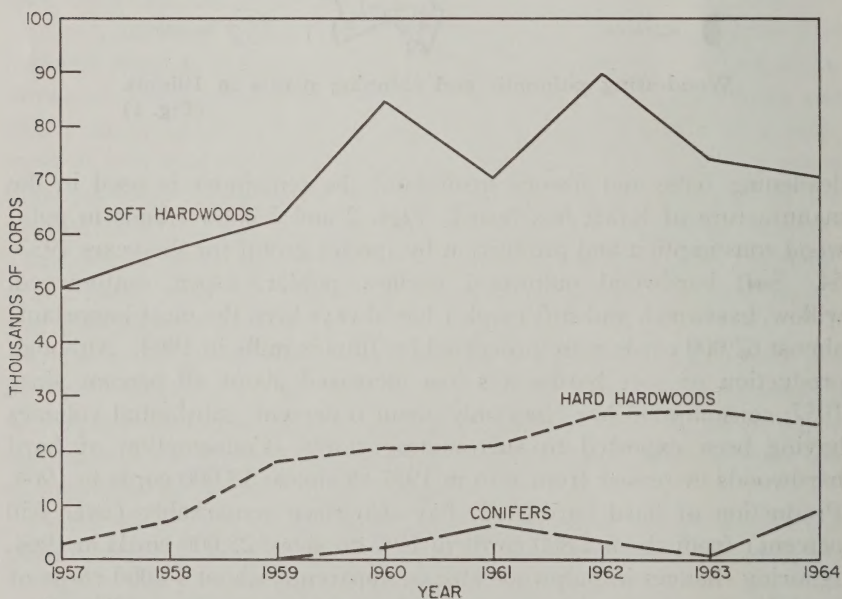
Wood-using pulp mills and chipping plants in Illinois.
(Fig. 1)

deadening felts, and fibrous insulation; the remainder is used in the manufacture of Kraft box board. Figs. 2 and 3 show trends in pulpwood consumption and production by species group for the years 1957-64. Soft hardwood pulpwood (yellow poplar, aspen, cottonwood, willow, basswood, and soft maple) has always been the most important; almost 67,000 cords were processed by Illinois mills in 1964. Although production of soft hardwoods has increased about 40 percent since 1957, consumption has risen only about 6 percent, substantial volumes having been exported to surrounding states. Consumption of hard hardwoods increased from zero in 1957 to almost 14,000 cords in 1964. Production of hard hardwoods has also risen remarkably (over 650 percent) from about 2,800 cords in 1957 to about 25,000 cords in 1964. Ignoring changes in pulpwood stocks, apparently about 10,000 cords of hard hardwoods have been exported to other states annually. Consumption of coniferous pulpwood, which is used in combination with



Consumption of pulpwood in Illinois from 1957 to 1964.

(Fig. 2)



Production of pulpwood in Illinois from 1957 to 1964.

(Fig. 3)

hardwoods in the manufacture of some fibrous products like box board, has remained unimportant over this period.

On balance, about 80 percent of all pulpwood bolts consumed in Illinois in 1963 were produced within the state. Twelve percent were imported from Indiana, 5 percent from Missouri, 1 percent from Kentucky, and 2 percent from Tennessee. At the same time, 43 percent of Iowa's pulpwood requirements and 9 percent of Indiana's came from Illinois.¹

There is one plant in southern Illinois and one in west-central Illinois which make only chips for use in the manufacture of box board. Both hard and soft hardwoods (except white oak, locust, and osage orange) and some pine pulpwood are chipped. Altogether, 5 of the 8 pulp and paper mills purchase chips; 3 of these purchase no roundwood, buying only chips and shavings, usually from local sources. Three mills purchase only roundwood, making their own chips or defibrating pulpwood some other way in their manufacturing processes.

Purchase of chips has become much more important in recent years. Whereas U. S. consumption of pulpwood in roundwood form increased about 38 percent between 1951 and 1961, consumption of chips increased over 575 percent.² The use of chips from wood-using plant residues is also increasing in Illinois. In 1964 residues accounted for about 20 percent of the pulpwood volume consumed in the state.

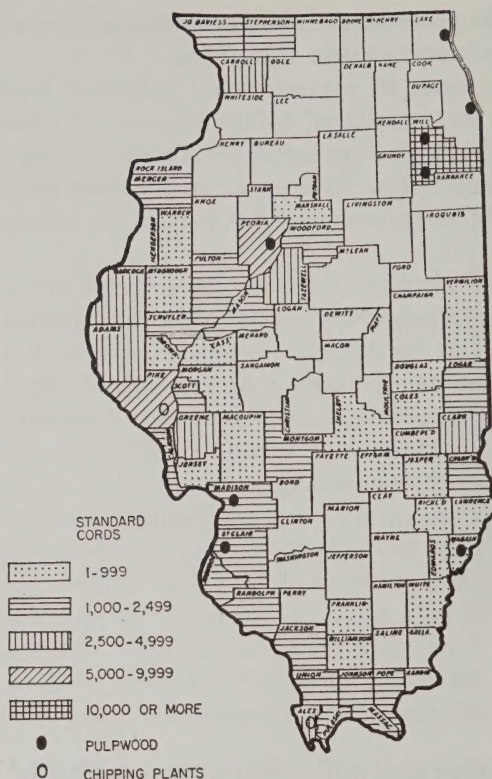
Pulpwood sources and mill procurement methods

The pulpmills of Illinois, Indiana, and Iowa drew pulpwood or chips from 54 counties in 1961 (Fig. 4). In general, pulpwood shipped out of the state moved short distances from some of the eastern and western counties to mills just across state borders. Heaviest production took place in Peoria, Pike, Will, Carroll, Tazewell, Hancock, Adams, Greene, Clark, and Alexander counties. Production remained essentially the same in most producing counties between 1960 and 1961, but a few counties (Stephenson, Hancock, Adams, Madison, St. Clair, Alexander, and Massac) experienced reductions in output (Fig. 5).

One-half of the raw material used by Illinois pulpmills in 1961 was purchased as roundwood; the other half as chips. None of the pulpmills had logging crews of their own; all roundwood pulpwood was purchased either from producers (57 percent) or through pulpwood

¹ Gansner, David A., "Pulpwood Production and Consumption in the Central States, 1962 and 1963," U. S. Forest Service Res. Note CS-23, 1964.

² Percentage of increases computed from data furnished by The American Pulpwood Association's monthly statistical reports, revised to conform to latest available Bureau of the Census data.

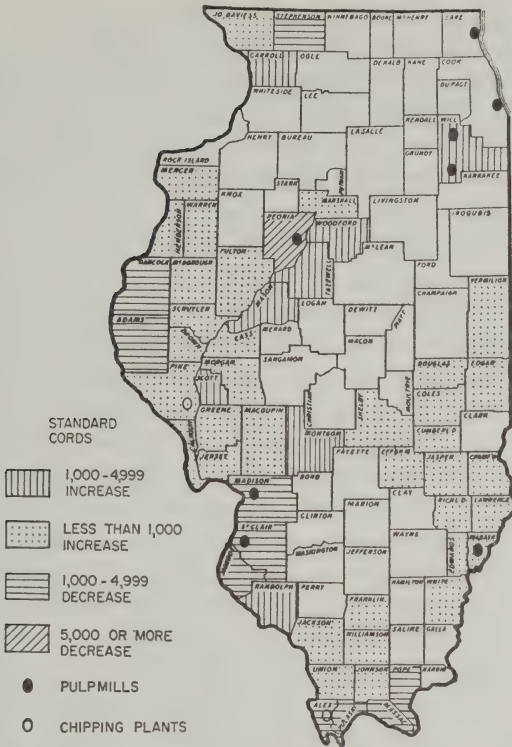


Round pulpwood production by counties in 1961. (Fig. 4)

agents or dealers (43 percent). Almost 73 percent of purchased chips came from chipping plants which themselves purchased the raw material in roundwood form; the remaining chips were derived from wood residues supplied by lumber mills and other local wood-using industries.

According to a 1958 Forest Service report, over 60 percent of all pulpwood purchased in Illinois was by the ton, about a quarter was purchased by the long cord, and the remainder by the standard cord.¹ Only one of the pulpmills reporting in the present study purchased pulpwood by the long cord; all others used the ton. Chips were universally purchased by the ton.

¹ McCauley, Orris D., "Pulpwood Prices and Measures in the Central States," Central States Forest Experiment Station Note No. 124, November 1958. The long cord measures 4' x 5' x 8' and contains 160 cubic feet, as compared with the standard cord, which measures 4' x 4' x 8' and contains 128 cubic feet.



Change in pulpwood production by counties from 1960 to 1961. (Fig. 5)

Pulpmills purchasing truck-delivered hardwood pulpwood in ton units paid \$5.50 to \$7.25 per ton. No distinction between soft or hard hardwoods was made. Mills paid \$12 to \$17 per ton for green chips delivered; chips derived from mill waste reportedly cost \$4.50 per ton f.o.b. the originating plants.

It is interesting to note that the chipping plants purchasing roundwood from producers or agents, or doing some of their own logging employed a 168-cubic-foot unit of pulpwood measure.¹ About one-half of all pulpwood used by chipping plants was purchased from producers. Of the remainder, almost all was produced under contract from pur-

¹ The 168-cubic-foot units apparently originated locally many years ago from the practice of cutting pulpwood sticks to a length of 5 feet 3 inches rather than 5 feet as in the long cord. The longer length stick was better adapted to the loading of railroad cars used in earlier pulpwood transport. Although such cars are no longer used, the measurements persist.

chased stumpage; one mill produced about 25 percent of its pulpwood needs using its own logging crew. Purchased pulpwood costs \$11 to \$15 per 168-cubic-foot unit, truck-delivered, or \$12 per standard cord f.o.b. railroad car. One chipping plant paid \$15 per cord to producers who delivered some minimum number of units per week and who had to haul wood 50 miles or more. Lower prices were sometimes paid to producers holding smaller contracts.

Half of the pulpmills in Illinois require written contracts with their pulpwood suppliers and half use oral contracts, but the greatest proportion of pulpwood purchased (70 percent by volume) is covered by written agreements. All chipping plants require written contracts.

Contracts, whether written or oral, specify the species which are acceptable. Usually all hardwood species, except hickory, locust, and osage orange, are acceptable; some mills will not accept oak. There does not appear to be any standardization of pulpwood length or diameter among mills. Most mills require pulpwood lengths between 4 and 7 feet; 5 feet is a fairly common length. There is even more variation in required minimum and maximum diameters. These vary from 2 to 4 inches as a minimum and 6 to 15 inches as a maximum. Contracts covering chipping plant pulpwood purchases are somewhat more standardized. Lengths must be no shorter than 5 feet 3 inches, but can be as long as 6 feet 3 inches or 7 feet 6 inches. Pulpwood sticks cannot be smaller than 4 inches in diameter but may be as large as 11 to 16 inches. All mills purchasing chips require chips to be $\frac{5}{8}$ inch.

Most mills buying pulpwood and those mills purchasing chips express satisfaction with present purchasing arrangements. Apparently there is little or no difficulty securing adequate pulpwood or chip deliveries, except when weather conditions slow down pulpwood cutting. Pulpmills in Illinois have been in operation for some time. Some of the more unreliable operators have been weeded out; the remaining suppliers, though fewer in number, are more dependable and handle relatively large volumes of pulpwood.

On the other hand, operators of the chipping mills express some dissatisfaction with present purchasing arrangements. The principal complaint is that suppliers tend to be unreliable. Chipping plant operators believe that high equipment costs and lack of woods skills are the chief problems facing their suppliers. In an attempt to alleviate this difficulty, chipping plants may offer their suppliers equipment, equipment repair services, or advance payment for operating capital. A few pulpmills also offer some of their producers advance payments in order to provide needed operating capital.

Six pulpmills representing 85 percent of the state's pulping capacity expected to increase their consumption of hardwood pulpwood in their operations; all were agreed that hardwood pulpwood was a completely satisfactory raw material. Some mills anticipated 20 to 25 percent increases in hardwood pulpwood consumption within the near future. Chipping mills also look forward to increased use of hardwoods; one mill expects to increase its use of pulpwood as much as 40 percent in the near future.

Marketing agents

Pulpmills secure needed wood from dealers and pulpwood producers. Dealers usually contract with producers for the purchase of the pulpwood, which is then sold to mills or chipping plants. Some pulpwood producers hold contracts with dealers; others produce directly for the mills or chipping plants. In Illinois, pulpwood dealers are not as important as in Michigan, one of the more important pulpwood states.¹ Dealers handled a little over 40 percent of all pulpwood sold to Illinois mills and chipping plants in 1961; in Michigan dealers frequently handle 50 to 60 percent of all pulpwood marketed annually.

Contracts between dealers and other producers are usually oral, but conditions of the transaction, such as species size, volume, and quality of pulpwood to be purchased, time and method of payment, and basis for measurement (mill scale), are almost always specified.

Pulpwood producers in Illinois include full-time timber operators and farmers who produce pulpwood occasionally. The full-time timber operators — those persons who spend most of their time logging sawtimber, pulpwood timber, or both — are the most important, both in terms of number and volume of pulpwood handled. It is estimated that full-time operators accounted for more than 70 percent of all pulpwood marketed by producers in Illinois during 1961. Farmers, acting as pulpwood producers, usually during the slack farming season, accounted for the remaining pulpwood (about 30 percent) sold to Illinois mills and chipping plants by producers.

With few exceptions, contractual arrangements between timber producers and timberland owners are oral. Almost always, unacceptable species are specified; sometimes size and quality specifications are also considered. Payments to landowners are usually made weekly for pulpwood removed. Measurement is almost always on a mill-scale basis.

¹ For a discussion of pulpwood marketing in this important pulp and paper-producing state, see James, L. M., *Marketing Pulpwood in Michigan*, Michigan State Univ. Agr. Exp. Sta. Spec. Bul. 411, February 1957.

This is different from sawtimber sales in Illinois, where the lump-sum sale is dominant. Farmer-producers operate in much the same way as timber operators; however, oral contract specifications tend to be less definite than those made by dealers who are agents and timber operators.

Average length of haul to pulpmills is about 29 miles, whereas average haul to chipping mills is a little less, 22 miles; hauling is mostly by truck. Hauling distances ranged from 3 to 50 miles. In general, each mill and chipping plant operates in a more or less isolated timbershed. Because of this isolation, neither pulpmills nor chipping plants compete with one another in the prices offered producers or dealers. Prices offered for pulpwood are determined by the relationship between a mill's wood requirements and the supply conditions in its timbershed; price policies of one mill do not appear to be affected by the policies of another mill operating in a separate timbershed.

Owners of woodlands in Illinois receive very little for pulpwood stumpage. In a number of cases, the pulpwood was given free of charge in exchange for the service of land-clearing. In the majority of sales transactions, pulpwood stumpage brought \$1.00 per cord (168 cubic feet) or 50 cents per ton.¹ Dealers who purchased pulpwood from producers for resale to mills or chipping plants paid an average of \$13 per cord (160 cubic feet), or \$5.50 per ton. At this rate and assuming mills pay \$16.25 per cord on the average, dealers receive \$2.00 or \$3.00 per cord for their marketing service, on the average.

Felling and bucking crews usually consist of two or occasionally three men. Timber operators frequently supervise several crews, whereas farmer-producers usually are a part of a single crew. Farmer-producers are more apt to arrange for others to do the hauling of the pulpwood they make, while timber producers more frequently have hauling crews of their own; only rarely do these consist of more than one man.

The use of power-driven chain saws is common. Every pulpwood producer, whether part- or full-time, indicated the use of chain saws in the pulpwood cutting and bucking operations.² Skidding is done almost

¹ A standard cord is a 4' x 4' x 8' stack of rough bolts. Factors used in converting to standard cords are: .8 long cord or unit; 4,500 pounds of soft hardwood roundwood; 5,000 pounds of hard hardwood or coniferous roundwood; 4,100 pounds of soft hardwood chips (green); and 4,300 pounds of hard hardwood or coniferous chips (green).

² Bucking is the process of cutting trees into pulpwood lengths after the removal of limbs (limbing). Skidding is the dragging of logs or trees from the point of felling to some central loading area.

entirely with farm tractors, but some large-scale producers use crawler-type tractors, some of which are equipped with winching devices. A few pulpwood producers make limited use of mules in the skidding operation, particularly during the winter months. Actually, skidding is kept to a minimum and is frequently a part of the loading operation. Usually, pulpwood is hand-loaded on trucks or trailers close to the cutting area. This can be done on many Illinois woodlands where the land is relatively flat or only moderately sloping.

Accurate pulpwood logging costs were not obtained because producers frequently do not keep separate account of felling, bucking, skidding, loading, and hauling costs. In a number of cases producers are unable to estimate even total logging and hauling charges.

Average total logging and hauling costs were estimated to be about \$8.30 per cord, but this figure must be interpreted with caution because producers usually could do little more than estimate costs themselves. Farmer-producers of pulpwood were unable to estimate logging or hauling costs in almost all cases. Most kept no records, even of total pulpwood production costs.

Very little data are available elsewhere on hardwood pulpwood-making costs. Some information which has applicability to Illinois conditions was collected recently in the Tennessee Valley.¹ Average production costs ranged from \$6.36 to \$13.84 per standard cord (128 cubic feet) and averaged \$9.28 where skidding was a separate operation. Where little or no skidding was done and scattered pulpwood was loaded by hand, costs per standard cord averaged \$8.98. Pulpwood-making in Illinois resembles this latter situation more than the former, but with at least two important differences: (1) Illinois pulpwood costs are figured on a 160-cubic-foot or 168-cubic-foot unit, whereas in the Tennessee Valley the costs refer to a standard 128-cubic-foot cord; and (2) Illinois felling and bucking crews usually consist of two men rather than one.

Landowners

Illinois farm woodlands furnish about 80 percent of the pulpwood cut in the state. Farmers are thus important woodland owners. Their actions regarding forest management and timber sales (sawlogs, veneer logs, stave bolts, and pulpwood) will determine the future importance of native wood in the primary and secondary wood-using industries of the state.

¹ Schnell, R. L., "Harvesting Costs for Hardwood Pulpwood in the Tennessee Valley," *Pulpwood Production and Sawmill Logging*, Vol. 12, Feb. 1964, pp. 22-25.

Farm woodland management does not appear to be an important objective of farmers in Illinois as yet. Of 18 farmers interviewed in connection with this study, and who disposed of pulpwood in 1960 and 1961, only 6 received any money for their stumpage; all of the others gave away their pulpwood (and in many cases sawlogs too) in return for land-clearing. Of the 6 owners who were paid, 3 received lump-sum payments and were unaware of the volumes removed; the other 3 were paid 50 cents per ton or \$1.00 per 168-cubic-foot cord as measured at the mill.

The reason given for selling or disposing of pulpwood stumpage by farmers was land-clearing in every case but one. The areas cleared varied from one-half acre to 45 acres. As far as future plans were concerned, most respondents indicated they would be willing to dispose of their pulpwood stumpage again in the same way. A few owners expressed dissatisfaction with the way cut-over areas were left after logging, and a few thought they would require payment for their stumpage next time. Only one owner expressed any intention of managing his woodland for income purposes; all of the others stated they would continue to clear-cut and put the land to other uses (grazing, for instance). Cut timber anytime it could be sold, or leave the cut-over area as it was without any plan to use it. If these intentions are representative of farmers who own pulpwood in Illinois, long-run pulpwood production may be seriously affected.

Pulpwood sales on public lands (principally national forests) are carried out under formal contracts which specify what trees are to be removed, prices to be received, and method of payment. Some pulpwood is also obtained from forest lands owned by the city of Chicago. All of these lands are under management, and although public pulpwood presently accounts for only a small part of the total pulpwood cut in Illinois, these lands will no doubt become much more important as a source of pulpwood in the future.

Market Outlook for Pulp and Paper Products

The possibilities for expansion of hardwood pulpwood marketing in the central states and Illinois will depend in large part on prospects for increased consumption of pulp and paper products. Pulp and paper manufacture is market-oriented, and although raw material supply, labor, transportation, and other factors are also important, availability of large markets reasonably close to manufacturing sites carries major weight. In this section we shall briefly examine pulp and paper market prospects.

Table 1. — U. S. Consumption of Pulp and Paper Board, 1960, and Estimated Consumption, 1970 and 1975, in Millions of Short Tons

	Consumption		Estimated consumption				
			1970		1975		
	1960 ^a	1962 ^b	Com- mittee on Inter- state and Foreign Com- merce ^c	U. S. Forest Service ^d	Stan- ford Re- search Insti- tute ^e	U. S. Forest Service ^f	Guthrie and Iulo ^g
Pulp.....	26.6	29.4	40.5	37.0	36.1	49.0	49.5
Paper and board..	39.2	42.2	55.6	52.7	53.5	60.0	65.0

^a U. S. Pulp Producers Association.

^b U. S. Department of Commerce, Bureau of the Census.

^c Committee on Interstate and Foreign Commerce, *Pulp, Paper and Board Supply-Demand*, 88th Congress, 1st Session, House Report No. 693, 1963.

^d *Timber Trends in the United States*, Forest Resource Report 17, February 1965.

^e *America's Demand for Wood, 1929-1975*, 1954.

^f *Timber Resources for America's Future*, Forest Resources Report 14, 1958.

^g Guthrie, J. A. and Iulo, William, *Some Economic Aspects of the Pulp and Paper Industry*, Northwest Pulp and Paper Assoc., Seattle, Washington, May 1963.

All national and regional studies dealing with prospective demand for pulp and paper products have projected substantial increases over present consumption. Table 1 summarizes a few pulp and paper and board projections made in recent years. Estimates made by the Stanford Research Institute were made in 1954 and appear to be quite conservative. Considering that projections of this kind are almost always too conservative, even those made by the Forest Service and Guthrie and Iulo¹ may be too low. Depending upon which projection is used, and considering that the U. S. will continue to import some paper, board, and pulp, the domestic production of pulp could run as high as 50 million tons in 1975. This would be an increase of almost 98 percent or roughly double the pulp production in 1960. The Forest Service, in its new appraisal of the U. S. forest situation, estimates that consumption of paper and board and of pulp may be as high as 69 million tons and 52 million tons, respectively, including net imports, by 1980.²

For our purposes a closer look at the present and prospective pulp and paper situation in the central states is also appropriate.³ About 26

¹ Guthrie, J. A., and Iulo, William, "Some Economic Aspects of the Pulp and Paper Industry," Northwest Pulp and Paper Assoc., Seattle, Wash., 1963.

² U. S. Forest Service, "Timber Trends in the United States," Forest Resource Report 17, February 1965.

³ In this report the central states included are Minnesota, Wisconsin, Michigan, Illinois, Indiana, Ohio, Iowa, and Missouri. These are the states which make up the central states region for official reporting of pulp and paper statistics.

**Table 2 — Paper and Paperboard Production (All Grades),
Central States Region, 1955-1962, in Short Tons^a**

Year	Total all grades	Percent of U. S. total	Paper, except con- struction paper	Con- struc- tion paper	Paper board	Wet ma- chine board	Insu- lating board and hard board
1955.....	7,457,621	25	3,173,086	541,089	3,410,869	53,079	279,498
1956.....	7,551,261	24	3,400,612	492,646	3,335,165	34,285	288,553
1957.....	7,287,633	24	3,246,024	460,418	3,271,037	30,384	279,770
1958.....	7,324,782	24	3,276,955	453,434	3,249,304	23,269	321,820
1959.....	8,043,933	24	3,544,341	477,635	3,570,358	25,583	426,016
1960.....	7,965,571	23	3,601,837	447,558	3,484,745	26,872	404,559
1961.....	7,988,833	22	3,648,913	446,925	3,445,203	26,362	421,430
1962.....	8,332,409	22	3,884,848	442,408	3,528,701	29,701	446,751

^a Includes the production of Minnesota, Wisconsin, Michigan, Indiana, Illinois, Ohio, Iowa, Missouri, and Kansas.

Source: U. S. Department of Commerce, Bureau of the Census, Facts for Industry, *Pulp, Paper and Board*, annual summary issues, Series M14A.

percent of all the people in the United States live in this region, compared with about 25 percent in the Northeast, 31 percent in the South, and about 15 percent in the West.¹ About one-third of the central states population is located in the three lake states; the remainder is found in the Mississippi and the Ohio Valley states.

Table 2 and Fig. 6 show production of paper and paperboards for the years 1955-1962. Over the years the central states region has accounted for somewhat less than 25 percent of the nation's paper and paperboard production; most of this has been concentrated in the lake states. In the region paper and paperboard consumption is believed to exceed production. Actual consumption figures are not available, but an estimate can be made by multiplying average U. S. per capita consumption of paper and paperboard (434 pounds) by the population of the region (46.7 million in 1960). Using these figures, consumption is estimated to have been about 10.14 million tons in 1960. Production in 1960 (see Table 2) was 7.97 million tons, leaving a deficit of about 2.17 million tons or 21 percent of total consumption. This deficit has been met by paper and paperboard shipments into the region from paper-surplus areas of the west, south, and northeast.

Considering production and consumption of woodpulp for paper and paperboard manufacture, the region is also deficit. Table 3 gives wood pulp production (all grades) and estimated consumption of wood

¹ Total population in the central states region, including Kansas, Nebraska, North Dakota, and South Dakota, was 51.6 million, or about 29 percent of the total population.

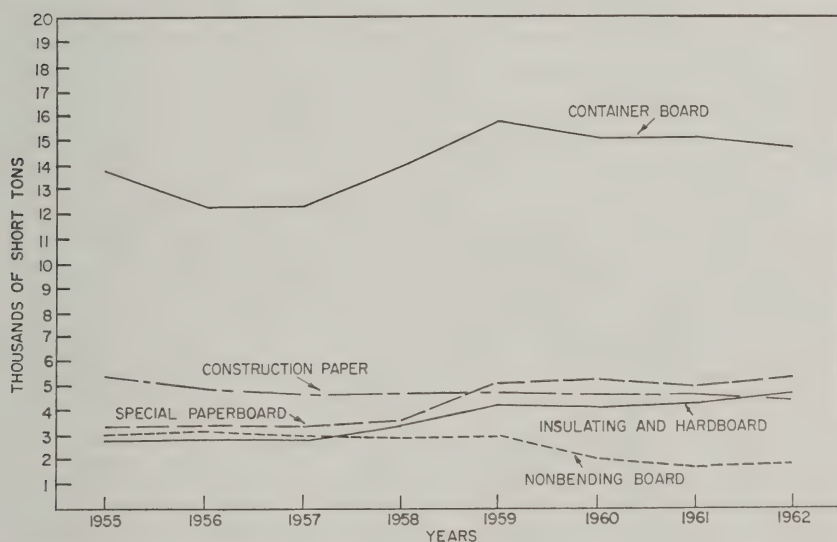
Table 3. — Comparison of Production and Consumption of Wood Pulp in Paper and Paperboard Manufacture, North Central Region, 1955-1962, in Thousands of Short Tons

Year	Central and lake states			Central states		
	Pro- duction ^a	Con- sumption ^b	Percent production is of consumption	Produc- tion	Con- sump- tion	Percent production is of consumption
1955.....	1,822	3,304	55	364	2,140	17
1956.....	1,931	3,367	57	383	2,109	18
1957.....	1,866	3,266	57	350	2,054	17
1958.....	1,964	3,322	59	381	2,025	19
1959.....	2,152	3,579	60	547	2,293	24
1960.....	2,394	3,634	66	359	2,181	16
1961.....	2,421	3,599	67	444	2,232	20
1962.....	2,507	3,784	66	513	2,298	22

^a Minnesota's production 1955-1959 estimated as 25 percent of lake states total production, based on reported production 1960-1962.

^b Consumption of pulp for paper and paperboard manufacture computed using a converting factor of 0.73 ton of wood pulp (all grades) for ton of paper and paperboard (all grades).

Source: U. S. Department of Commerce, Bureau of the Census, Facts for Industry, *Pulp, Paper and Board*, annual summary issues, Series M14A. Converting factor from U. S. Department of Commerce, Bureau of the Census, *Census of Manufacturers*, 1958.



Paper and paperboard production in the central states region from 1955 to 1962. (Fig. 6)

pulp for the manufacture of paper and paperboard for the lake states and central states for the years 1955-1962. On the average, it requires 0.72 ton of new wood pulp to manufacture a ton of paper and paperboard (all grades combined); the remainder being other fibrous ma-

terial, primarily waste paper. According to Table 3, lake states pulp production is sufficient for two-thirds of the area's paper and paperboard manufacturing needs. Pulp production in the remainder of the north central region falls far short of the region's needs, accounting for only about 22 percent of consumption. Despite the fact that pulp production now accounts for a greater percentage of consumption than formerly, it has been necessary to ship into the region large quantities of market pulp from the pulp surplus areas of the west and south.

Table 4 indicates that, as with total paper and paperboard production, central states production of all but two types of paperboards is presently a smaller percentage of total U. S. production than in 1955. The exceptions are insulating and hardboards and construction boards. The decline in relative importance of regional paper and paperboard production, with the noted exceptions, reflects at least in part the rapid expansion in pulp and paper production in the south and west and increasing competition from these regions resulting from widespread adoption of the sulphate and semichemical pulping processes. In the central states, production of insulating and hardboards has increased 60 percent since 1955, while special paperboard increased 55 percent. This is in contrast to output of the other types of papers and paperboards which have remained essentially the same or have declined. Despite increased production of special paperboard in absolute volume over the period, central states' production accounts for a smaller proportion of total U. S. production than formerly.

The increasing relative importance of the central states region in the production of insulating and felting materials and hardboards is probably related to the concentration of population in this region (26 percent of total U. S. population in 1960), the large volume of construction in this area (over 26 percent of total value of all construction in the U. S. in 1960), the transportation cost advantage the region enjoys over producers of these materials in the west and south, and the decline of insulating and hardboard production in the south from 61 percent in 1955 to 52 percent of total U. S. production in 1962.

As noted in Table 1, U. S. consumption of paper, paperboards, and pulps are expected to increase substantially by 1970 and 1975. This increased consumption will require stepped-up production and very likely some increase in imports of both paper and pulp. The central states will no doubt share in these expected increases. Table 5 shows a possible pattern of paper and paperboard production for the central states region in 1970, using the Committee on Interstate and Foreign

Table 4. — Central States Production of Paperboards, Construction Paper, and Insulating and Hardboards as a Percentage of U. S. Production, 1955-1962, in Thousands of Short Tons

Year	Total paperboard ^a		Container board		Bending board ^b		Nonbending board		Special paperboard ^c		Total construction and paperboard		Construction paper		Insulating and hardboard	
	M tons	Pct.	M tons	Pct.	M tons	Pct.	M tons	Pct.	M tons	Pct.	M tons	Pct.	M tons	Pct.	M tons	Pct.
1955....	3,422	25	1,406	19	1,332	34	300	29	343	27	821	26	541	34	279	17
1956....	3,335	23	1,371	18	1,279	31	307	29	334	27	781	25	493	34	289	18
1957....	3,271	23	1,371	18	1,265	30	293	28	341	27	740	26	460	35	280	18
1958....	3,249	23	1,392	18	1,236	29	281	29	341	26	775	26	453	33	322	20
1959....	3,570	23	1,561	19	1,311	30	191	24	508	28	904	27	478	33	426	22
1960....	3,485	22	1,530	18	1,242	28	201	26	512	28	852	27	448	32	405	23
1961....	3,445	21	1,492	16	1,291	29	171	23	492	25	868	27	447	32	421	23
1962....	3,529	20	1,527	15	1,298	28	177	28	527	24	889	26	442	31	447	23

^a Does not include wet machine board, construction paper, or insulating and hardboards.

^b Folding boxboard and special foodboard.

^c Cardboard, bending board, other than folding boxboard and special foodboard, and nonbending board other than setup boxboard.

Source: U. S. Department of Commerce, Bureau of the Census, Facts for Industry, *Pulp, Paper and Board*, annual summary issues, Series M14A.

Table 5. — Projected U. S. and Central States Paper and Paperboard Production Requirements, 1970, in Thousands of Short Tons^a

Grade	Estimated total U. S., 1970	Central States	
		Percent of U. S. production, 1962 ^b	Projected product, 1970 ^c
All paper.....	21,329	23	4,906
All paperboard.....	23,974	20	4,795
All construction paper.....	1,526	31	473
All building board.....	2,757	22	607
Total.....	49,586	22	10,781

^a Estimated total U. S. projected production from Committee on Interstate and Foreign Commerce, *Pulp, Paper, and Board Supply-Demand*, 88th Congress, 1st Session, House Report 693, 1963, p. 73.

^b Data rounded to nearest percent.

^c Central states projected productions are 1962 percentages of 1970 estimates.

Table 6. — Estimated Pulp Requirements to Satisfy Projected Paper and Paperboard Production, Central States, 1970, in Thousands of Short Tons

Produced grade	Estimated production of paper and paperboard	Estimated ratios, tons of total wood pulp to ton of product ^a	Estimated pulp requirements
All paper.....	4,906	.85	4,170
All paperboard.....	4,795	.62	2,973
All construction paper.....	473	.27	128
All building board.....	607	.80	486
Total.....	10,781	.72	7,757

^a 1958 ratios from U. S. Department of Commerce, Bureau of the Census, *Census of Manufacturers*, 1958.

Commerce projections, and assuming this region accounts for about the same proportion of paper and paperboard production in 1970 as in 1962. Table 6 shows the conversions of the central states' paper and paperboard projections to the volumes of pulp which would be needed to satisfy manufacturing requirements.

About 7.9 million tons of pulp would be needed annually for paper and paperboard manufacture in the central states by 1970. If the central states become relatively more important, and this could occur in the manufacture of particular kinds of pulp products such as insulating and hardboards, pulp requirements would be somewhat higher. It must be noted, however, that the region presently does not provide for more than one-half of its pulp needs. According to the data in Table 3, pulp production in 1962 was only about 3 million tons compared with about 6.1 million tons consumed in paper and paperboard manufacture.

If the pulp-producing capacity of the region grows only enough to maintain its present position over the next five years, production of pulp (all grades) would be 4 million tons annually by 1970.

We may check this figure indirectly by applying the central states proportion of total U. S. pulp production in 1962 (10.8 percent) to estimated total projected domestic pulp production in 1970, assuming no change in the relative position of the region's pulp manufacturing position. In this case production in 1970 would again be 4 million tons (10.8 percent of 37.2 million tons), roughly one-half of the 7.9 million tons needed to supply projected paper and paperboard needs.

The implications for pulp, paper, and paperboard expansion in the central states are clear. Should the assumption regarding the economic forces underlying projected pulp and paper estimates be met at the assumed levels, then the projections are in fact forecasts of consumption for 1970. If the factor levels are not reached as assumed, then actual consumption and production will differ from the projections to an appropriate degree. In both cases we are assuming that projection and forecasting techniques are adequate for the purposes at hand. In any event regional consumption of pulp (all grades combined) is very likely to increase by at least 30 percent (6.1 to 7.9 million tons) and production by 33 percent (3 to 4 million tons) over 1962 levels. Finally, supply is assumed to be forthcoming to meet increased demands if projections are viewed as future consumption and production requirements.

In the case of the central states region, the alternative to meeting increased production needs is a decline in the importance of pulp and paper manufacture and greater reliance on in-shipments to satisfy increased demands. The potential market for pulp and paper products is substantial. It could be even more so if more paper and pulp products were developed and adopted by industry and a growing population. We must now ask what factors and forces in the central states, and more particularly in Illinois, will determine the extent to which supply will be expanded to meet increased demands and the relative importance of each.

Pulp and Paper Industry Location Decisions

The establishment of new plants or the expansion of present facilities involve careful consideration of a variety of items. In general, profit maximization and cost considerations are paramount. However, the location may be significantly influenced by noneconomic factors. For instance, one location may seem more promising from strictly a

cost minimization standpoint, but another economically less attractive one may be chosen because it can better provide the community services which would be demanded by workers in the new plant.

The relative importance of locational factors will depend upon the kind of industry concerned. For instance, the factors involved in a decision to establish a new sawmill, and the importance attached to each factor, will differ in several respects from those involved in a decision to establish a new pulpmill. In both cases wood supply, labor costs, and transportation charges are involved, but the relative importance of each of these will differ among the industries. Furthermore, the availability of some resources may be critical for one kind of plant location, but unimportant for another. Thus the availability of water in sufficient quantity and quality is essential for the establishment of certain kinds of pulpmills; it is usually much less important where one is considering the establishment of a sawmill. Aside from water, several other resources and services must be evaluated in a study of expanded pulp and paper manufacturing in Illinois.

A plant location decision is said (Malinowski and Kinnard) to involve investigation at three levels: (1) primary level, (2) secondary level, and (3) tertiary level.¹ In this scheme, primary level factors include demand and market considerations which presumably help delineate location possibilities at a regional level. Secondary level factors, such as availability of transportation facilities, tax advantages, and power facilities, influence costs and help narrow the site alternative to one or more communities within the region. Tertiary level factors, such as drainage, soil conditions, space for expansion, and in some cases existing buildings, determines the final site location. It is not necessary that each level be examined successively; some location decisions may involve a consideration of two or three levels at once. Furthermore, one decision-maker may consider a factor to be important at a primary or secondary level, while another may believe it to be important at the tertiary level only. This analysis is concerned only with an examination of primary and some secondary factors. As noted earlier, a consideration of tertiary factors would require a study of individual plant sites and lies beyond the scope of this report.

Pulp and paper manufacture is both market and raw-material oriented. Market considerations are important because pulp products

¹ Malinowski, Z. S., and Kinnard, W. N., Jr., "Personal Factors Influencing Small Manufacturing Plant Locations," report prepared by the University of Connecticut for the Small Business Administration, Washington, D. C., June 1961.

are bulky and expensive to transport. On the other hand, because pulp and paper mills represent very large capital investments requiring very long amortization periods, a long-run pulpwood supply is essential; the industry thus tends to be raw-material oriented also. Before wood became the chief raw material, pulpmills were located near population centers. As wood became more important, the location decision involved a choice between producing near the raw material source and shipping to market (raw-material orientation) or producing near markets and transporting the raw material to the mill (market orientation).¹

It appears that for a great majority of industries the location of input resources and services and of markets exert a dominant locational pull.² In pulpmill location, market prospects frequently represent the beginning point for the locational decision, but raw material sources must also be considered.

Once the market or primary level decision has been made, all of the other locational factors must be considered in some way. Generally, these will relate to cost of inputs and particularly those inputs which vary in price among the location alternatives. The principal economic factors usually considered in pulp and paper plant location decisions are those investigated by Hagenstein;³ these are water, pulpwood, labor, forest land, electricity, rail and highway transportation, industrial site, state and local taxes, and local financial assistance.

Chemicals contribute significantly to total pulping costs, but they do not vary substantially among alternative plant locations. This is because prices for standard chemicals (like sulphur, soda ash, chlorine, and caustic soda) tend to be equalized industry-wide. Furthermore, chemical manufacturers absorb differences in freight costs, enabling most locations to compete on a more or less equal basis with regard to chemical costs. The exception to this general rule is sulphur. However, the nearness of Illinois locations to the principal sulphur-producing areas in Texas and Louisiana reduces the importance of freight charges on this chemical as far as a location decision is concerned.

¹ Hunter, Helen, "Innovation, Competition, and Locational Changes in the Pulp and Paper Industry, 1880-1950," *Land Economics*, 31 (1955), pp. 314-327.

² Perloff, H. S., "Lagging Sectors and Regions of the American Economy," *The American Economic Review*, Vol. L, May 1960, No. 2, pp. 223-230.

³ Hagenstein, P. R., "The Location Decision for Wood-Using Industries in the Northern Appalachians," U. S. Forest Service Res. Paper NE-16, 1964, Northeastern For. Exp. Sta., Upper Darby, Pa. The method used here for estimating the relative importance of the input factors (cost substitution) was developed by Hagenstein.

Hagenstein developed a system for ranking the most important input factors whose cost will ordinarily vary by location. Not included in his rating system is the availability of water and the effect this would have on plant site location. The system uses a "cost of substitution" idea, which is defined as the percentage of change in the cost of a particular factor that is equivalent to a 10 percent change in cost of one of the more important factors, such as pulpwood. Average regional costs which are assumed to be applicable to the industry are used as a basis for these calculations. For a 200-ton per day pulpmill using a semi-chemical pulping process and hardwood pulpwood, Hagenstein found the following rates of substitution among the inputs (in percent):

Wood.....	10
Transportation.....	20
Labor.....	36
Electricity.....	44
State and local taxes.....	64
Forest land.....	647
Local financial assistance.....	1,050
Industrial site.....	2,400

The factor requirements and prices used in these computations are:

<i>Input</i>	<i>Requirements</i>	<i>Prices</i>
Pulpwood	280 cords per day	\$16 per cord
Labor	32 skilled	\$2.70 per hour
	16 semi-skilled	\$1.35 per hour
	16 unskilled	\$1.20 per hour
Forest land	30,000 acres where competition is strong; none otherwise	\$7.50 per acre excluding timber
Electricity	55,000 kilowatt-hours per day	\$0.018 per kilowatt-hour
Transportation to principal markets	Rail and highway	\$11.00 per ton
Industrial site	100 acres	\$500.00 per acre
Investment in plant and equipment	\$10,000,000	6 percent
State and local taxes	....	2½ percent of sales dollar

The input factors for which substitution rates are computed are those whose factor prices vary by location, since these are relevant to the location decision. However, looking at the substitution percentages above, it is obvious that such large differences in value could not arise

merely because of location. For example, although it is possible that pulpwood price could vary by 10 percent from one location to another, it is much less likely that labor charges would vary by 36 percent, or electricity by 44 percent; it is quite unlikely that forest land would vary by 647 percent. If these differences do not arise because of location, then they represent factor interrelations and can be used to rank the relative importance of the several inputs for the industry concerned. Thus, the smaller the cost substitution rate value, the more important is that factor in the location decision, assuming an objective of the manager is to minimize costs in the proposed new location.

If each of the cost substitution values is divided into the rate for the most important factor (pulpwood), the factors can be arranged by importance as follows:

Pulpwood.....	1.00
Transportation.....	0.50
Labor.....	0.28
Electricity.....	0.23
State and local taxes.....	0.02
Forest land.....	0.0020
Local financing.....	0.0010
Industrial site.....	0.0004

This ranking very likely holds reasonably well in Illinois, even if the size of mill and factor prices vary from those in the northern Appalachians. The most important input factors are pulpwood, transportation, labor, and electricity; overriding these inputs in importance is, of course, availability of water in sufficient quantity and quality for whatever pulping process is contemplated and the availability of an adequate site adjacent to the water resource. It is interesting to note the low importance of state and local taxes, forest land, and local financing. The relatively low rank of forest land is a reflection of the very general availability of hardwood pulpwood supply. In Illinois, as elsewhere, ownership of forest land by pulpmills using hardwoods is not crucial because the wood procurement area of one mill does not seriously overlap the procurement area of any other. Pulpmills have not found it necessary as yet to own forest land in order to assure a long-term pulpwood supply or to influence pulpwood market prices through cutting of owned pulpwood. The low rank of state and local taxes and local financial assistance suggests that state or local industrial and economic development agencies which try to encourage new industry through tax concessions and financial assistance are not very effective as far as new pulpmills are concerned.

Adequacy of Water Resources

Water requirements

Water requirements vary widely with the pulping process used and the kind of pulp product manufactured. In general, the chemical pulping processes require large volumes of water per ton of pulp because the waste water (effluent) is charged with chemicals and other materials which must be properly diluted upon entering receiving streams so that fish and aquatic life may be protected.

Groundwood and other nonchemical pulping methods require much less water per ton of pulp because chemicals are not used to separate the wood fibers in the pulping process. In the groundwood process, wood fibers are produced through the abrasion of pulpwood against revolving grindstones; water is used to float away the fibers and cool the stones. In the Asplund and Masonite pulping processes, roundwood is heated by steam under pressure and defibration occurs when the pressure is suddenly released. Here, water is needed to produce the steam and also to carry away the fibers. Bleaching of wood pulps, however they are produced, increases water requirements. Total water requirements will also depend on the kind of product being manufactured.

The future expansion of pulp and paper manufacture in Illinois will be closely conditioned by the character of the state's forest resource as well as the availability of water. Timber stands in Illinois are composed almost entirely of hardwood species. With the development of the Kraft (sulfate) and semi-chemical processes, which can utilize almost any kind of pulpwood, hardwood pulpwood has become an important source of raw material for pulp and paper production in several of the central states. The nonchemical pulping processes can also utilize hardwoods in the manufacture of a number of pulp products, including hardboards, insulating boards, roofing felts, bulk fibers, and heat-molded wood fiber products.

The amount of water needed to manufacture a ton of wood pulp or a ton of the finished product can vary widely, even among plants using the same process, because of differences in plant size, layout, and equipment. Table 7 gives estimated average water use values for the principal pulp and paper products of concern in Illinois; several representative estimates are given for each process or product. Most of the water used in the chemical processes may be recirculated within the mill but is eventually discharged as effluent.

The data in Table 7 give some idea of the water needed to process a ton of pulp or pulp product. Thus, an integrated Kraft pulp and

Table 7. — Representative Water-Use Estimates, Based on Individual Mills, for Selected Pulp and Paper Products, in Gallons per Ton

Product	Water use
Kraft (sulfate) pulp.....	92,000 ^a 36,400
	Average 64,000
Groundwood pulp.....	16,000 7,350
	Average 12,000
Kraft paper from pulpwood.....	82,000 65,000 45,000 41,000 31,000
	Median 44,000
Felts and boards.....	11,000 8,000 6,600 2,400 2,200
	Median 5,900
Semichemical pulp.....	9,700 ^b

^a Includes water used in by-product plant.

^b Source: U. S. Forest Service, Forest Products Laboratory, Pulp Manufacturing Information, Report WFPR-89, revised, July, 1962.

Source: Mussey, O. D., "Water Requirements of the Pulp and Paper Industry." U. S. Geological Survey Water-Supply Paper 1330-A, Washington, D. C., 1961.

paper plant with a daily capacity of 200 tons per day would use 8,800,000 gallons of process water per day, on the average. This would require a stream discharge flow of about 13.6 cubic feet per second. (One million gallons per day is equivalent to a flow of 1.55 cubic feet per second.) However, the amount of water needed to dilute pulping plant effluents to a safe level for aquatic life may be much higher. The minimum stream flow required will depend on the kind of pulping process and water treatment method being used, the size of the mill, the temperature of the stream water, and the amount of oxygen dissolved in the water before discharge.

The alkaline pulping processes, such as the sulfate process, which can use hardwood pulpwood in the manufacture of strong wrapping papers and container boards, do not cause serious pollution problems because most of the spent liquors can be concentrated and burned with recovery of the alkali. Residual effluent from a sulfate mill too large for the receiving stream can cause trouble, however.¹ Treatment can

¹ U. S. Forest Service, Forest Products Laboratory, "Pollution of Streams from Pulp and Paper Mills," Report 1207, Madison, Wisconsin, December 1956.

consist of ponding or lagooning of effluents for oxidation, or direct oxidation through treatments like those in municipal sewage disposal systems.

Other residues from both sulfate and soda-pulping processes can cause stream problems. Sulphur ethers or alcohols called mercaptans, and which have very disagreeable odors, are poisonous to fish if present in concentrations greater than about one part per million. Ordinarily mercaptan concentrations can be kept very low. Another possible pollutant of sulfate effluent is precipitated calcium carbonate. Unless this precipitate is filtered off and properly eliminated, it can form a calcareous deposit in the stream bed for several miles downstream of the mill.

From the stream pollution standpoint, effluents from the semichemical pulping processes are more of a problem than are the wastes from the sulfate process. In the semichemical pulping processes, the acid chemical concentrations dissolve some of the wood, and the spent liquor produced may contain significant amounts of carbohydrate material (sugars). When the material is discharged into streams, the rapid growth of bacteria, yeasts, and molds is encouraged; the dissolved oxygen content of the water is rapidly lowered; and aquatic life may be quickly destroyed. As with the sulfate process, effluents from the semichemical pulping methods usually must be treated. This is not easily accomplished, unless semichemical plants are integrated with chemical pulping plants (sulfate or cold soda), in which case the semichemical liquors can be combined with those from sulfate and soda process and recovered in the usual systems.

Effluents from groundwood pulpmills consist mainly of fiber wastes which result from the washing and screening of mechanically produced pulp. Although these wastes are nonchemical in nature and have little effect on the oxygen content of stream water, they can become a nuisance because of odor, color, and unsightliness. Mills producing groundwood pulps ordinarily control this source of pollution by special machinery which removes the fibers and conditions the waste water for reuse.

The principal problem involved in pulpmill stream pollution is the demand of mill wastes on the dissolved oxygen content of the receiving stream water near the mill site and for a distance downstream. Streams are self-purifying, but their capacity to recover from lowered oxygen levels depends on the volume and rate of water flow.

A measure of the depletion of oxygen by mill waste is called the "biochemical oxygen demand" (BOD) and is measured in terms of the

pounds of dissolved oxygen that will be consumed by the effluent from each ton of pulp produced. The following tabulation gives the relative polluting capacities of effluents from several of the more important pulping processes:

	<i>BOD (approximate), in pounds per ton of pulp</i>
Groundwood pulping	3- 8
Sulfate (Kraft) pulping.....	55- 70
Semichemical pulping	125-275
Sulfite pulping	400-600

The semichemical and sulfite values are for untreated effluents; as noted above, groundwood effluents are generally nontoxic, and practically all sulfate pulpmills treat their wastes and recover chemicals for reuse.

In Illinois, industrial wastes must be treated or otherwise modified before discharge in order to maintain the following conditions in receiving waters:¹

1. Freedom from anything that will settle to form putrescent or otherwise objectionable sludge deposits which interfere with reasonable water uses.

2. Freedom from floating debris, scum, and other floating materials in amounts sufficient to be unsightly or deleterious.

3. Freedom from materials producing odor or color in such a degree as to create a nuisance.

4. Freedom from substances in concentrations or combinations which are toxic or harmful to human, animal, or aquatic life.

Illinois regulations state that the above conditions are basic or minimum requirements. Furthermore, intermediate, secondary, or special treatment may be required for industrial wastes before their discharge into streams and waters in order to maintain reasonable standards of purity. In any particular location the State Sanitary Water Board, in consultation with appropriate engineering and other technical associates, would determine the required treatment. Ponding and spraying of effluent prior to its return to the stream are means of reducing effluent contamination.

It is possible to estimate the approximate size or capacity of a prospective mill which can be operated at a given mill site and still maintain the required dissolved oxygen content of the receiving stream water. In order to do this, certain information must be available:

¹ State of Illinois, Sanitary Water Board, Division of Sanitary Engineering, Department of Public Health, "Basic Industrial Waste Disposal Requirements," Tech. Release 20-11, Springfield, Ill., 1960.

1. The five-day biochemical oxygen demand (BOD) per ton of pulp to be produced.
2. The average highest temperature of water to be expected in the stream during the year.
3. The average lowest rate of stream flow expected during the year.
4. The average dissolved oxygen level in parts per million of the stream water at the average highest temperature to be expected.
5. The minimum amount of dissolved oxygen in parts per million in a stream required for the support of aquatic life.

An example of how this information can be used to estimate allowable mill capacity is as follows:¹

Assume a stream flow of 2,500 cubic feet per second, a water temperature of 75° F., and a permissible reduction in dissolved oxygen content of the stream, before reaching the minimum requirement for fish life, of 4 parts per million. It is also assumed that at 75° F. a five-day BOD loading rate of 11 pounds per day will consume 1 part per million of dissolved oxygen at a stream flow rate of 1 cubic foot per second. In this case the stream could safely receive effluent equivalent to 110,000 pounds BOD per day, computed as follows:

Permissible BOD load = (flow rate in feet/sec.) × (BOD rate in pounds of oxygen at 75° F.) × (allowable reduction in O₂ in parts per million) = (2,500) (11) (4) = 110,000 pounds per day

Using the BOD values for effluents from the different pulping processes, the following size mills could be built at this site:

1. A sulfite mill with a daily capacity of about 180 tons of bleached pulp without treatment (chemical recovery).
2. A semichemical (neutral sulfite) mill with a daily capacity of about 400 tons of bleached pulp without treatment.
3. One or more sulfate mills with a total daily capacity of 1,500 tons of bleached pulp.
4. A number of groundwood pulpmills with a total capacity of about 13,000 tons of bleached pulp per day.

Surface water availability

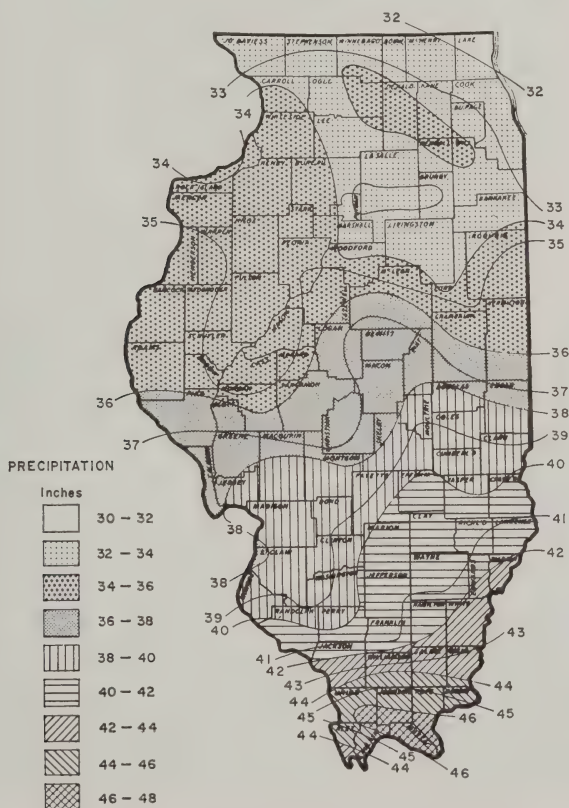
A next logical step in this analysis is to examine the adequacy of Illinois water resources to see where and to what extent pulp manufacture can be expanded.

¹ U. S. Forest Service, Forest Products Laboratory, "Pulp Manufacturing Information," Report WFPR-89, revised July 1962.

In general, Illinois is considered a water excess state; water available to the state is conservatively estimated to be at least five times the present usage.¹ An average of about 99 billion gallons of water falls daily upon the state in the form of rain or snow. Some 76 billion gallons per day are returned to the atmosphere through evaporation and transpiration. Some 23 billion gallons per day from streams and groundwater are also available within the state which, when added to the minimum flow of water in the Mississippi and Ohio rivers, as well as the water diverted from Lake Michigan, brings the total average daily surface and groundwater supplies to about 43 billion gallons.

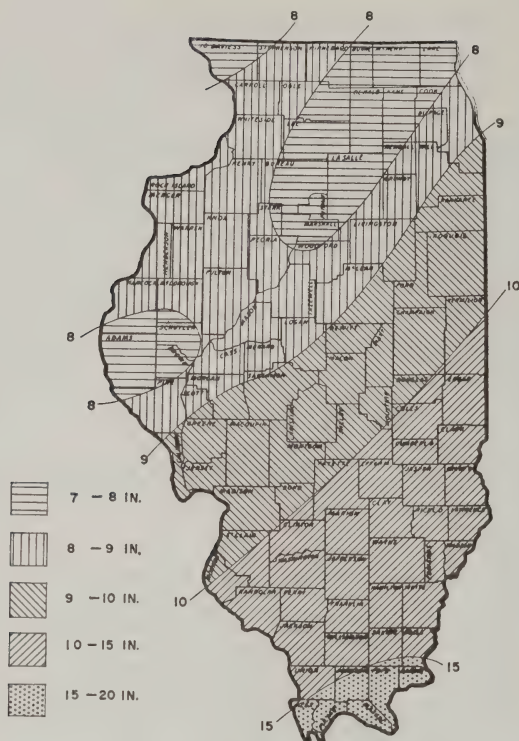
Although generally plentiful, water is not necessarily available in sufficient quantity or quality where it is needed. Rainfall, runoff, and stream flow govern availability of surface water. Fig. 7 shows the

¹ State of Illinois, Division of Industrial Planning and Education, *Atlas of Illinois Resources*, Section I, "Water Resources and Climate," p. 1, Springfield, Ill., 1958.



Average annual rainfall in Illinois.

(Fig. 7)

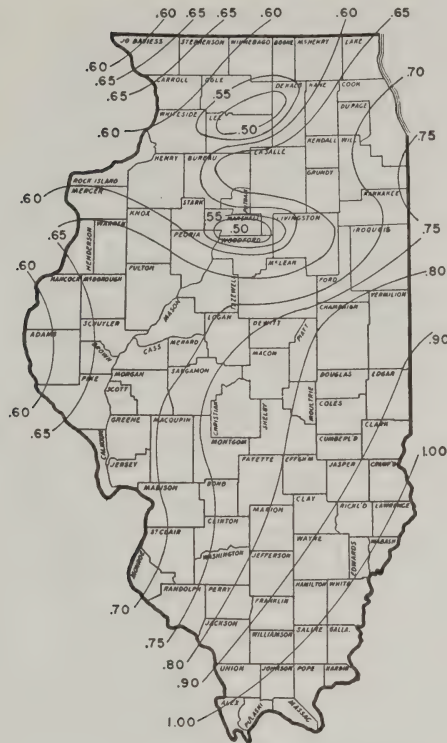


Average annual water runoff in Illinois.
(Fig. 8)

average annual precipitation for the state. Precipitation is lowest in the northeastern part of the state near Lake Michigan and highest in the hill region of southern Illinois. Generally, the southern half of the state is much better watered than the northern half.

Fig. 8 shows the average annual runoff for the state. Of the 99 billion gallons which fall in Illinois daily as rain or snow, about 23 billion gallons eventually run off into streams. Runoff ranges from 8 inches per year in the northern part of the state to over 15 inches in the southern part. The runoff pattern is generally consistent with the precipitation pattern shown in Fig. 7.

Precipitation and runoff patterns suggest that surface waters should be more available as one moves southward through the state. This is confirmed by the pattern of average stream discharge shown in Fig. 9. In Fig. 9 stream discharge is shown in cubic feet per second per square



Average stream discharge in cubic feet per second per square mile of watershed. (Fig. 9)

mile of watershed. Again, the lowest values are found in the northern part of the state, and the highest in the southern part.

Although precipitation, runoff, and stream flow are highest in the southern half of the state, daily discharge variability of interior streams becomes progressively greater from north to south. Fig. 10 shows the stream discharge variability pattern for Illinois. The variability index measures stream discharge rate variation over some unit of time (day, week, month, or year). Differences in the variability index indicate differences in variability between one stream and another or one region and another. The lines in Fig. 10 represent lines of equal stream flow variability. The higher the index value, the greater the range of discharge to be expected. Higher stream flow variation in southern Illinois is related to generally steeper topography. Thus, although more water falls on the southern counties, and more of this

Table 8. — Allowable BOD Loads per 24 Hours^a

River flow point	Rate of flow	Allowable loads per 24 hrs.
	(cubic feet per second)	(pounds)
Mississippi River at Chester.....	30,000	1,320,000
Mississippi River at Thebes.....	23,400	1,029,600
Ohio River at Metropolis.....	20,600	906,400
Mississippi River at St. Louis.....	18,060	792,000
Mississippi River at Alton.....	7,960	350,240
Mississippi River at Clinton.....	6,500	286,000
Mississippi River at Keokuk.....	5,000	220,000
Illinois River at Meredosia.....	3,060	134,640
Illinois River at Kingston Mines.....	2,300	101,200
Wabash River at Mt. Carmel.....	1,620	71,280
Illinois River at Marseilles.....	1,460	64,240
Rock River near Joslyn.....	834	36,696
Rock River at Rockton.....	501	22,044
Rock River at Como.....	498	21,912
Kankakee River at Momence.....	306	13,464
Kankakee River near Wilmington.....	204	8,976

^a Biochemical Oxygen Demand in pounds of oxygen per day, assuming water temperature of 75° F. and a permissible reduction in dissolved oxygen content of 4 parts per million.

Source: Data on stream flow rates from U. S. Department of Interior, Geological Survey, "Water-Supply Characteristics of Illinois Streams," issued by Division of Waterways, State of Illinois, 1950.

greens. Using the lowest average stream flows, a relatively high average water temperature of 75 degrees, an average dissolved oxygen content of 8 ppm, and an allowable reduction in the oxygen content of 4 ppm, the allowable BOD loads per 24 hours are computed (Table 8) for several Illinois locations.

As far as water requirements are concerned, it is apparent that considerable pulping capacity could be installed at or near many of the points noted in Table 8. Table 9 shows possible pulping capacities based on surface water availability alone. Later examination of the availability of other productive factor requirements in the areas surrounding these locations, especially pulpwood, will determine further their relative attractiveness for pulp mills. The locations listed in Table 9 and unspecified points downstream are probably the only ones with sufficient dependable water flow for pulping purposes. Only sites along the Mississippi and Ohio rivers could support semichemical pulp mills of more than 500 tons per day capacity. The Wabash and Illinois, as well as the Mississippi and Ohio, rivers have sufficient flow to support 500 tons per day chemi-mechanical mills. Interior Illinois streams, other than listed in Table 9 do not carry enough water during the dry season, or are too variable to be dependable sources of pulping process water.

Table 9. — Potential Daily Pulping Capacity Based on Water Availability Alone, in Tons

River point	Allowable BOD loads per 24 hrs.	Potential pulping capacity ^a		
		Semi- chemical	Chemical- mechanical	Kraft
Mississippi River at Chester.....	1,320,000	4,800	13,200	18,850
Mississippi River at Thebes.....	1,029,600	3,740	10,300	14,710
Ohio River at Metropolis.....	906,400	3,300	9,065	13,000
Mississippi River at St. Louis.....	792,000	2,900	7,920	11,315
Mississippi River at Alton.....	350,240	1,275	3,500	5,000
Mississippi River at Clinton.....	286,000	1,040	2,860	4,080
Mississippi River at Keokuk.....	220,000	800	2,200	3,140
Illinois River at Meredosia.....	134,640	490	1,345	1,925
Illinois River at Kingston Mines..	101,200	370	1,010	1,445
Wabash River at Mt. Carmel.....	71,280	260	715	1,020
Illinois River at Marseilles.....	64,240	230	640	915
Rock River near Joslyn.....	36,696	130	365	525
Rock River at Rockton.....	22,044	80	220	315
Rock River at Como.....	21,912	80	220	315
Kankakee River at Momence.....	13,464	50	135	195
Kankakee River near Wilmington	8,976	30	90	130

^a Approximate BOD used is 275 pounds per ton for semichemical, 100 pounds for chemical-mechanical, and 70 pounds for Kraft pulping.

Groundwater availability

Neither the groundwood nor the Kraft pulping processes require large volumes of water, particularly if the resulting effluent is subject to treatment. This raises the possibility of establishing such mills in areas where stream flow is not adequate for other pulping processes or where surface waters can be supplemented by groundwater.

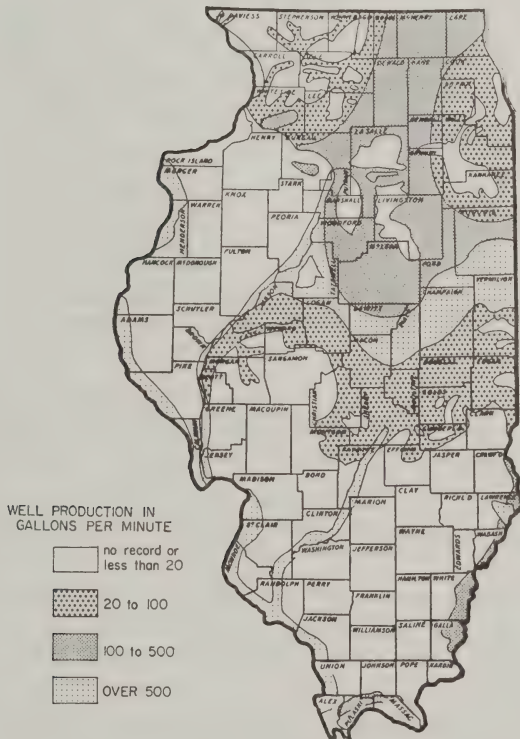
Sand and gravel glacial deposits and limestone and sandstone bed-rocks are the principal sources of groundwater in Illinois. These formations, called aquifers, vary greatly in water-yielding capacity and are distributed unevenly over the state.

Much of Illinois is covered by unconsolidated glacial debris to varying thicknesses. There are three kinds of glacial deposits: till, outwash, and loess. Till is a mixture of soil and rock deposited directly by the ice. Outwash is composed mainly of sands, gravels, and silts spread by glacial meltwaters. Loess is wind-blown silt from river flats deposited sometimes to a great depth over other deposits of till and outwash.

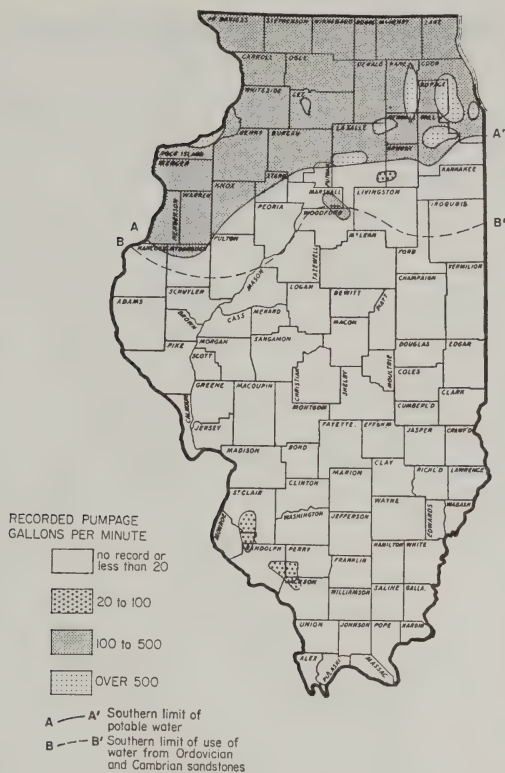
Outwash sands and gravels are an important source of groundwater in Illinois. These materials were deposited mainly in old stream systems and valleys leading away from retreating ice fronts. In these areas

large quantities of groundwater are available at relatively shallow depth. Some of the old stream systems are occupied by streams today, among them the valleys of the Mississippi River, the Wabash River, and lower two-thirds of the Illinois River and the Kaskaskia River. Other old valleys were completely buried by glacial deposits; the Mahomet Valley in east-central Illinois is an example. Fig. 11 shows the general distribution of sand and gravel aquifers in Illinois. The eastern one-third of the state contains the bulk of the productive sand and gravel aquifers; these are less extensive or absent in the southern and western parts of the state, except along the major rivers.

Another principal source of groundwater is the limestone and sandstone bedrock aquifers. Silurian and Devonian dolomites are sources of groundwater in northeastern and northwestern Illinois as shown in



Location of sand and gravel aquifers in Illinois, and recorded well-water production. (Fig. 11)



Location of sandstone aquifers and their recorded pumpage in gallons. (Fig. 13)

yield 300 to 1,500 gallons per minute. Water from sandstones tends to be highly mineralized and would probably require treatment before use in certain pulping processes. The lines A-A' and B-B' in Fig. 13 show the southern limits of potable and usable water (less than 1,500 ppm total dissolved solids) from sandstone aquifers in Illinois.

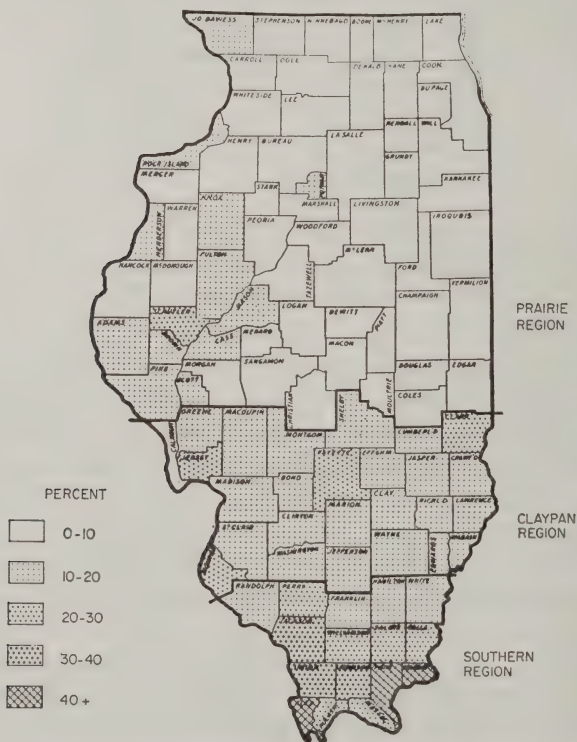
Although surface waters constitute the principal source of pulping process water which would be required for pulping expansion, it is apparent that groundwater could be also used along the major stream systems where productive sand and gravel aquifers are to be found. Some limestone and sandstone aquifers look promising also as far as water requirements are concerned. Unfortunately the more productive limestone and sandstone aquifers are not located in the more heavily forested regions of the state where pulpwood sources are to be found.

Adequacy of Pulpwood Supplies

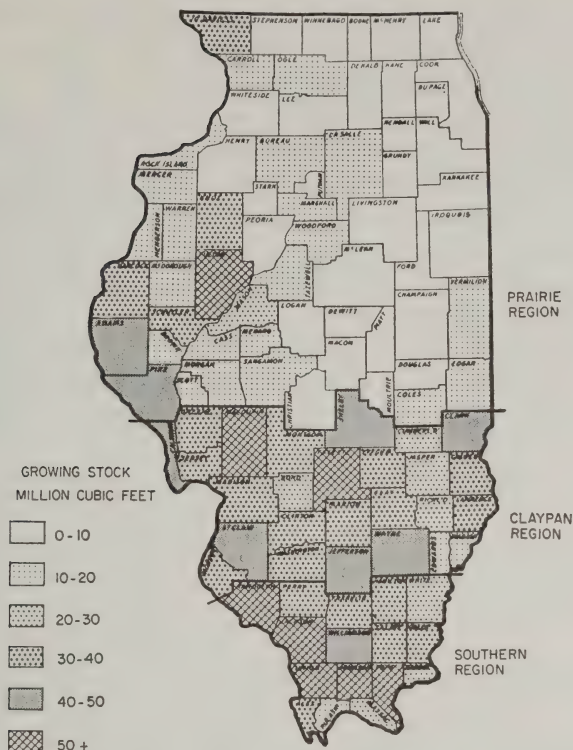
According to the latest forest survey of Illinois (1962), about 11 percent of the state's total land area is commercial forest land.¹ The following tabulation and Fig. 14 show that the southern counties are by far the most heavily forested:

	Prairie region	Claypan region	Southern region	Total
Total land (acres).....	23,376,600	8,485,100	3,933,500	35,795,200
Commercial forest land (acres).....	1,349,900	1,392,800	1,128,600	3,871,300
Percent commercial forest land.....	5.6	16.1	27.6	11

¹Commercial forest land is land capable of producing crops of industrial wood (timber products other than fuelwood and fence posts) and not withdrawn from timber utilization.



Commercial forest land area in Illinois in 1962.
(Fig. 14)



Timber volume in Illinois counties in 1962.
(Fig. 15)

Commercial forest land represents the basic forest land resource, but the presence or absence of growing stock on any given area also determines the present and, to a considerable extent, future opportunities for timber harvest and forest management. The forests of Illinois contain 2.3 billion cubic feet of growing stock volume,¹ including 8.6 billion board feet of sawtimber.

The claypan region contains 40 percent of the state's timber growing stock volume, including 39 percent of the sawtimber volume. The prairie region follows with 31 percent of the growing stock volume and 33 percent of the sawtimber volume. The southern region contains 29 percent of the state's growing stock volume and 28 percent of its sawtimber volume. Despite its third ranking in terms of total timber

¹ Growing stock is the net volume in cubic feet of live sawtimber trees (11.0 or over in dbh) and live poletimber trees (5.0-11.0 dbh) from stump to a minimum 4-inch top inside the bark.

volume, the southern region is the more attractive pulpwood supply area. Timber tracts are more concentrated in a smaller area, contributing to lower procurement and transportation costs.

Fig. 15 shows volume of growing stock by county. In the prairie region only Fulton and Schuyler counties, along the Illinois River, and Jo Daviess, Hancock, Adams, and Pike counties, along the Mississippi River, contain relatively heavy timber volumes. Six counties in the southern region (Randolph, Jackson, Union, Johnson, Pope, and Williamson) alone account for 376.3 million cubic feet or 16 percent of the state's entire growing stock.

Virtually all of Illinois' growing stock (99.3 percent), including sawtimber, is in hardwood timber. Sawtimber trees comprise 65 percent of this growing stock, and poletimber size trees comprise 35

Table 10. — Volume of Growing Stock on Commercial Forest Lands by Species, 1962^a

Species	Volume	Percent of total
	(thousand cubic feet)	
Softwoods		
Shortleaf and loblolly pine.....	10,910	..
Cypress.....	3,729	..
Other.....	1,556	..
Total softwoods.....	16,195	1
Hardwoods		
Select white oak.....	401,794	17
Select red oak.....	149,934	6
Other white oak.....	80,991	4
Other red oak.....	351,487	15
Total oak.....	984,206	42
Hickory.....	235,009	10
Hard maple.....	63,903	3
Soft maple.....	177,695	7
Beech.....	8,389	..
Sweet gum.....	54,573	2
Tupelo and blackgum.....	10,681	..
Ash.....	157,913	7
Cottonwood and aspen.....	95,401	4
Basswood.....	15,784	1
Yellow poplar.....	21,417	1
Black walnut.....	44,935	2
Other.....	458,129	20
Total other than oak.....	1,343,829	57
Total hardwoods.....	2,328,035	99
Total all species.....	2,344,230	100

^a Essex, B. L., and Gansner, D. A., *Illinois Timber Resources*, Lake States Forest Exp. Sta., St. Paul, Minn., 1965 (U. S. For. Ser. Resource Bul. LS-3).

Table 11. — Volume of Growing-Stock Trees on Commercial Forest Land, by Species and Size-Class, 1962^a

Species	Pole-timber size	Sawtimber size	Total
(thousand cubic feet)			
Softwoods			
Shortleaf and loblolly pine.....	9,535	1,375	10,910
Cypress.....	8	3,721	3,729
Other.....	1,146	410	1,556
Total softwoods.....	10,689	5,506	16,195
Hardwoods			
Select white oak.....	107,725	294,069	401,794
Select red oak.....	25,881	124,053	149,934
Other white oak.....	35,748	45,243	80,991
Other red oak.....	118,911	232,576	351,487
Hickory.....	121,801	113,208	235,009
Hard maple.....	24,269	39,634	63,903
Soft maple.....	56,272	121,423	177,695
Beech.....	449	7,940	8,389
Sweet gum.....	11,810	42,763	54,573
Tupelo and blackgum.....	3,113	7,568	10,681
Ash.....	72,673	85,240	157,913
Cottonwood and aspen.....	17,941	77,460	95,401
Basswood.....	3,902	11,882	15,784
Yellow poplar.....	4,812	16,605	21,417
Black walnut.....	21,765	23,170	44,935
Other.....	182,797	275,332	458,129
Total hardwoods.....	809,869	1,518,166	2,328,035
Total all species.....	820,558	1,523,672	2,344,230

^a Essex, B. L., and Gansner, D. A., *Illinois Timber Resources*, Lake States Forest Exp. Sta., St. Paul, Minn., 1965 (U. S. For. Ser. Resource Bul. LS-3).

percent. Thus the present inventory is still dominated by sawtimber, although further examination will indicate that much of this material is of low quality.

Table 10 shows growing stock volume by species. Select white oak is the most important single species group. The second most important group is red oak, other than select red oak; all of the red oaks together account for 21 percent of the total growing stock volume. Hickory, soft maple, and ash are also important species.

Table 11 shows that except for select red oak, beech, and cottonwood-aspen about one-third of the hardwood growing stock volume is in trees less than sawlog size. Some of the volume in these tree sizes is suitable for pulpwood and should be removed to improve stand conditions.

In addition to the volume in pole-size timber, much of the growing stock volume is in sawlog-size trees that could also be used for pulp-

Table 12. — Volume of Hardwood Sawlog Volume by Log Grade, 1962^a

Species	Log grade			
	All grades	Grade 1	Grade 2	Grade 3
		(thousand board feet)		
Select white oak.....	1,722,150	115,300	115,870	1,490,980
Select red oak.....	751,620	49,860	13,720	688,040
Other white oak.....	253,980	18,810	15,360	219,810
Other red oak.....	1,338,730	43,930	31,120	1,263,680
Hickory.....	620,520	20,490	36,110	557,920
Hard maple.....	233,840	15,210	15,640	202,990
Soft maple.....	624,030	11,980	23,880	588,170
Beech.....	45,760	.....	.....	45,760
Sweetgum.....	235,760	37,000	19,050	179,710
Tupelo and blackgum.....	41,030	7,140	1,260	32,630
Ash.....	427,810	46,500	24,310	357,000
Cottonwood and aspen.....	462,620	46,050	11,820	404,750
Basswood.....	66,490	.....	1,820	64,670
Yellow poplar.....	96,800	.....	6,060	90,740
Black walnut.....	114,360	9,190	14,870	90,300
Other.....	1,512,950	76,600	65,450	1,370,900
Total.....	8,548,450	504,060	396,340	7,648,050

^a Essex, B. L., and Gansner, D. A., *Illinois Timber Resources*, Lake States Forest Exp. Sta., St. Paul, Minn., 1965 (U. S. For. Ser. Resource Bul. LS-3).

wood. Table 12 shows that 7.6 billion board feet, or almost 90 percent of the sawlog inventory, is of low quality (Log Grade 3). Further, more than one-third of the sawtimber-size trees are less than 16 inches dbh, a size suitable for pulpwood production.

For the first time total volume of growing stock, including sawtimber volume, is available on a county basis. Fig. 15 shows, in a general way, which counties contain the most growing stock volume. Table 13, gives the estimated county growing stock and sawtimber volumes. Even though none of the counties in the prairie region show much commercial forest land, at least seven counties (Adams, Fulton, Hancock, Knox, Pike, and Schuyler) contain substantial timber volumes. The prairie region contains a total of about 728 million cubic feet of timber.

Regionally, the claypan region (Table 13) contains the greatest volume of timber. Only 6 out of the 26 counties contain less than 30 million cubic feet of growing stock. The region contains a little less than 1 billion cubic feet of timber. The southern region contains a little over 687 million cubic feet of growing stock concentrated within a 16-county area. Only 4 of these contain less than 30 million cubic feet.

Table 13. — Volume of Growing Stock and Sawtimber by County and Species Class, 1962^a

County	Growing stock			Sawtimber		
	All species	Soft-woods	Hard-woods	All species	Soft-woods	Hard-woods
	(thousand cubic feet)			(thousand board feet)		
Prairie region						
Adams.....	44,659	40	44,619	155,130	50	155,080
Brown.....	20,366	8	20,358	66,630	20	66,610
Bureau.....	14,915	...	14,915	53,610	10	53,600
Carroll.....	12,632	8	12,624	46,350	10	46,340
Cass.....	19,078	71	19,007	74,780	110	74,670
Christian.....	8,105	15	8,090	36,660	20	36,640
Coles.....	12,308	8	12,300	42,070	20	42,050
Edgar.....	10,080	...	10,080	36,950	10	36,940
Fulton.....	52,464	32	52,432	176,770	60	176,710
Hancock.....	31,932	24	31,908	115,020	30	114,990
Henderson.....	18,028	16	18,012	61,890	30	61,860
Jo Daviess.....	34,207	24	34,183	119,520	20	119,500
Knox.....	30,723	24	30,699	112,860	30	112,830
La Salle.....	14,204	...	14,204	45,460	...	45,460
McDonough.....	17,443	23	17,420	61,280	20	61,260
Marshall.....	16,069	...	16,069	54,660	10	54,650
Mason.....	23,645	24	23,621	81,240	40	81,200
Menard.....	8,808	7	8,801	36,220	20	36,200
Mercer.....	15,381	15	15,366	55,200	20	55,180
Morgan.....	17,767	16	17,751	61,550	20	61,530
Ogle.....	14,220	166	14,054	51,170	100	51,070
Peoria.....	25,580	24	25,556	90,200	20	90,180
Pike.....	46,642	32	46,610	153,490	40	153,450
Putnam.....	8,872	...	8,872	33,850	10	33,840
Rock Island.....	19,971	15	19,956	73,630	20	73,610
Sangamon.....	10,705	...	10,705	54,870	20	54,850
Schuyler.....	33,520	24	33,496	114,840	40	114,800
Scott.....	11,850	8	11,842	42,790	20	42,770
Tazewell.....	16,314	24	16,290	59,270	30	59,240
Vermilion.....	16,321	15	16,306	58,460	30	58,430
Warren.....	12,940	...	12,940	48,470	10	48,460
Whiteside.....	8,880	...	8,880	30,750	10	30,740
Woodford.....	13,651	...	13,651	50,660	10	50,650
Other.....	65,673	190	65,483	434,940	200	434,740
Total.....	727,953	853	727,100	2,791,240	1,110	2,790,130
Claypan region						
Bond.....	23,542	40	23,502	82,190	150	82,040
Calhoun.....	44,193	142	44,051	159,990	750	159,240
Clark.....	42,139	8	42,131	149,070	...	149,070
Clay.....	30,810	134	30,676	122,660	780	121,880
Clinton.....	39,255	261	38,994	162,150	1,510	160,640
Crawford.....	31,466	103	31,363	117,070	540	116,530
Cumberland.....	25,699	79	25,620	91,030	410	90,620
Edwards.....	15,263	79	15,184	58,540	420	58,120
Effingham.....	33,780	39	33,741	111,840	150	111,690
Fayette.....	63,832	126	63,706	223,550	690	222,860

(Table is concluded on next page)

Table 13. — Concluded

County	Growing stock			Sawtimber		
	All species	Soft-woods	Hard-woods	All species	Soft-woods	Hard-woods
	(thousand cubic feet)			(thousand board feet)		
Greene.....	32,690	55	32,635	114,320	300	114,020
Jasper.....	28,480	8	28,472	89,860	...	89,860
Jefferson.....	41,799	47	41,752	144,660	220	144,440
Jersey.....	37,509	47	37,462	131,130	180	130,950
Lawrence.....	31,545	103	31,442	115,310	600	114,710
Macoupin.....	56,366	134	56,232	201,870	720	201,150
Madison.....	35,013	103	34,910	119,760	250	119,510
Marion.....	39,571	39	39,532	127,180	150	127,030
Monroe.....	34,728	55	34,673	124,310	190	124,120
Montgomery.....	32,532	95	32,437	118,980	520	118,460
Richland.....	26,031	79	25,952	93,880	430	93,450
St. Clair.....	43,110	269	42,841	168,560	1,510	167,050
Shelby.....	42,028	103	41,925	146,250	530	145,720
Wabash.....	12,782	87	12,695	61,890	520	61,370
Washington.....	34,997	119	34,878	31,450	700	130,750
Wayne.....	49,888	174	49,714	182,560	980	181,580
Total.....	929,048	2,528	926,520	3,350,060	13,200	3,336,860
Southern region						
Alexander.....	39,476	276	39,200	152,910	610	152,300
Franklin.....	36,285	111	36,174	132,650	540	132,110
Gallatin.....	38,204	1,367	36,837	146,850	1,750	145,100
Hamilton.....	36,743	150	36,593	127,260	780	126,480
Hardin.....	26,536	1,714	24,822	90,730	700	90,030
Jackson.....	92,549	751	91,798	327,500	1,800	325,700
Johnson.....	51,911	213	51,698	175,450	570	174,880
Massac.....	26,173	158	26,015	104,860	770	104,090
Perry.....	34,926	158	34,768	118,200	110	118,090
Pope.....	77,823	5,822	72,001	227,150	2,810	224,340
Pulaski.....	16,819	87	16,732	86,750	540	86,210
Randolph.....	55,000	71	54,929	200,750	380	200,370
Saline.....	32,295	1,446	30,849	95,000	870	94,130
Union.....	54,518	285	54,233	200,890	420	200,470
White.....	23,447	126	23,321	100,270	690	99,580
Williamson.....	44,524	79	44,445	147,910	330	147,580
Total.....	687,229	12,814	674,415	2,435,130	13,670	2,421,460

^a Essex, B. L., and Gansner, D. A., *Illinois Timber Resources*, Lake States Forest Exp. Sta., St. Paul, Minn., 1965 (U. S. For. Ser. Resource Bul. LS-3).

An estimate of how much of the state's timber volume could be made available as pulpwood can be made through examination of Tables 11, 12, 14, and 15. Table 14 compares net annual growth, annual cut (1961), and desirable cut by broad species groups and regions. Desirable cut is much larger than current annual cut and is defined as the net volume of merchantable timber that may be cut annually during the current decade while progressively affecting a reasonably even

Table 14. — Net Annual Growth, Annual Cut, and Desirable Cut of Growing Stock and Sawtimber by Species Class, 1962^a

Species class	Net annual growth	Annual cut	Desirable cut
(thousand cubic feet)			
Growing stock			
Softwoods.....	1,313	458	732
Hardwoods.....	83,807	29,672	111,469
Total.....	85,120	30,130	112,201
Sawtimber			
Softwoods.....	1,260	2,270	2,030
Hardwoods.....	207,520	173,030	448,330
Total.....	208,780	175,300	450,360

^a Essex, B. L., and Gansner, D. A., *Illinois Timber Resources*, Lake States Forest Exp. Sta., St. Paul, Minn., 1965 (U. S. For. Ser. Resource Bul. LS-3).

distribution of age classes during the optimum rotation selected for each timber type, and while building up to a desirable level of good growing stock to meet the future needs. The cut is at a level that could be sustained in subsequent decades and includes both harvest and intermediate commercial cuttings. In any one location such a cut would have to yield at least 3 cords or 500 board feet in total volume, not including cull volumes.

Much of the poor-quality sawlog material (1.3 billion cubic feet) which presently dominates the state's timber inventory is in the 12-, 14-, or 16-inch diameter class. Some of this could be removed, while enhancing the growth on the remaining inventory. To this amount, the volumes in trees below 9 inches in diameter could be added (495 million cubic feet) for a total of low-quality material of about 1.8 billion cubic feet. Much of this volume could best be utilized for pulpwood.

Based on the timber resource situation, the claypan and southern regions can be considered as suitable potential pulpwood supply areas. Timber stands in most of the prairie region are probably too scattered for economical pulpwood harvesting and transport. However, the area comprising Hancock, Adams, Pike, Schuyler, Knox, and Fulton counties might be an attractive pulpwood supply area for a mill located on the Illinois River or near its confluence with the Mississippi. Or these counties might be tributary to a mill or mills located somewhere in the claypan region.

Although the volume of wood represented in improvement cuttings could serve as a substantial backlog supply of pulpwood, the feasibility

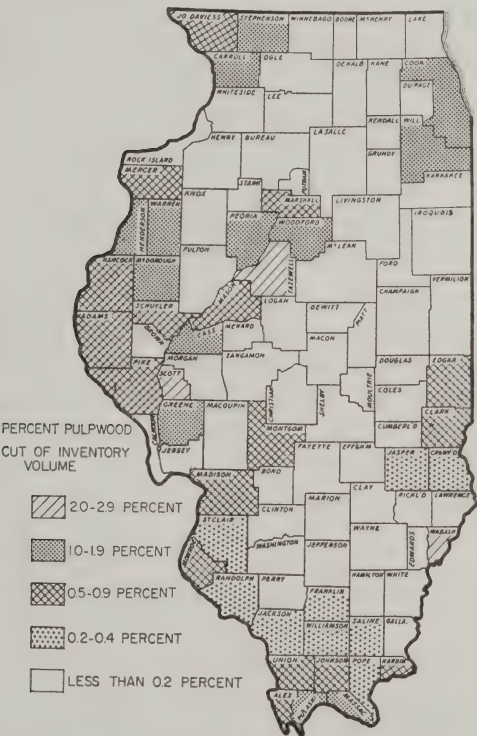
Table 15. — Annual Desirable Cut of Growing Stock and Live Sawtimber by Species and Region, 1962

Species	All regions	Prairie	Claypan	Southern
(thousand cubic feet)				
Growing stock				
Softwoods				
Shortleaf and loblolly pine.....	320	.....	.....	320
Cypress.....	347	.....	218	129
Other.....	65	57	1	7
Total softwoods.....	732	57	219	456
Hardwoods				
Select white oak.....	22,603	9,612	7,647	5,344
Select red oak.....	7,774	4,040	1,997	1,737
Other white oak.....	4,265	.....	2,537	1,728
Other red oak.....	14,500	2,532	6,781	5,187
Hickory.....	10,773	2,236	4,901	3,636
Hard maple.....	3,896	2,236	973	687
Soft maple.....	8,835	3,200	3,523	2,112
Beech.....	641	.....	326	315
Sweet gum.....	3,137	.....	1,917	1,220
Tupelo and blackgum.....	508	.....	256	252
Ash.....	7,356	1,688	3,505	2,163
Cottonwood and aspen.....	2,587	1,351	667	569
Basswood.....	1,020	840	111	69
Yellow poplar.....	1,022	.....	532	490
Black walnut.....	1,698	888	480	330
Other.....	20,854	7,621	8,126	5,107
Total hardwoods.....	111,469	36,244	44,279	30,946
Total all species.....	112,201	36,301	44,498	31,402
Live sawtimber				
Softwoods				
Shortleaf and loblolly pine.....	20	.....	.....	20
Cypress.....	1,940	.....	1,210	730
Other.....	70	70	.....	.....
Total softwoods.....	2,030	70	1,210	750
Hardwoods				
Select white oak.....	104,980	45,620	35,090	24,270
Select red oak.....	42,640	23,540	10,570	8,530
Other white oak.....	14,270	.....	8,420	5,850
Other red oak.....	62,930	9,970	30,440	22,520
Hickory.....	33,740	7,310	14,940	11,490
Hard maple.....	14,120	9,020	2,950	2,150
Soft maple.....	32,960	13,040	12,360	7,560
Beech.....	3,270	.....	1,760	1,510
Sweet gum.....	14,200	.....	8,660	5,540
Tupelo and blackgum.....	1,840	.....	940	900
Ash.....	23,080	5,120	11,050	6,910
Cottonwood and aspen.....	11,920	6,510	3,000	2,410
Basswood.....	4,450	3,930	320	200
Yellow poplar.....	4,440	.....	2,400	2,040
Black walnut.....	5,790	3,480	1,360	950
Other.....	73,700	26,520	28,920	18,260
Total hardwood.....	448,330	154,060	173,180	121,090
Total all species.....	450,360	154,130	174,390	121,840

^a Essex, B. L., and Gansner, D. A., *Illinois Timber Resources*, Lake States Forest Exp. Sta., St. Paul, Minn., 1965 (U. S. For. Ser. Resource Bul. LS-3).

of building new pulp capacity will depend mainly on the level of pulpwood cut which can be sustained over a long period of time. The estimates of annual desirable cut shown in Table 15 are indicative of the volumes which could be cut annually, and which would build up a desirable growing stock over time. Most of this cut would be best suited for pulpwood.

Another way to assess the volume that is available for cutting but that is not being cut is to compare the volume of pulpwood cut from a county with the county timber inventory volume. Cut and inventory for 1962 are compared in Fig. 16. The current pulpwood harvest ranges from zero percent of the inventory volume in many counties to a high of 2.9 percent. In only three counties did the pulpwood cut in 1962 exceed 2 percent of inventory volume, and it exceeds 1 percent in only 15 counties. Timber growth averages approximately 3.6 percent of timber inventory on a state-wide basis; thus it appears that the 1962



Relation of pulpwood cut to growing stock inventory in 1962. (Fig. 16)

Table 16. — Estimated Feasible Daily Pulping Capacity by Region and Pulping Process, Based on Pulpwood Resource

Pulping process	Cords of wood per ton of pulp	Claypan region	Southern region	Total estimated daily capacity
		Estimated daily capacity	Estimated daily capacity	
		tons	tons	tons
Groundwood.....	.93	1,525	1,095	2,620
Exploded wood.....	.93	1,525	1,095	2,620
Sulfite.....	1.94	745	525	1,270
Sulfate.....	1.64	880	620	1,500
Soda.....	1.79	805	570	1,375
Semichemical.....	1.20	1,205	850	2,055

pulpwood cut did not reach or exceed the average annual growth increase in any Illinois county.

It is possible to estimate daily pulping capacity, by pulping process, which could be supported by the estimated desirable cut. Table 16 shows these pulping capacities for the claypan and southern regions, assuming all of the material to be economically available. The information is based on the following estimated annual volumes of desirable cut:

Claypan region — 44,498,000 cubic feet, including 28,472,000 cubic feet (64 percent) of sawtimber

Southern region — 31,402,000 cubic feet, including 19,783,000 cubic feet (63 percent) of sawtimber

Assuming 10 percent of sawtimber volume in each region is Log Grade 2 or higher and would be used for sawlogs, veneer logs, cooperage bolts, etc., then the desirable cut figures representing the volume highly suitable for pulpwood are as follows:

Claypan region — 41,650,800 cubic feet or 527,225 cords of solid wood (79 cubic feet per cord)

Southern region — 29,423,700 cubic feet or 372,450 cords of solid wood (79 cubic feet per cord)

71,074,500 cubic feet or 899,675 cords of solid wood (79 cubic feet per cord)

The groundwood, exploded wood, and semichemical processes are the pulping methods best suited to Illinois hardwoods. Thus the volume of pulpwood available in the claypan region is adequate to sustain several groundwood or exploded wood pulpmills totaling 1,525 tons per

day; or several semichemical mills with a total daily capacity of 1,205 tons. The estimates for the southern region are 1,095 tons for groundwood or exploded wood pulping and 850 tons for semichemical pulping. Present capacity of all pulpmills operating in Illinois is estimated to be 848 tons per day. Thus the pulpwood volume physically present in both regions combined is sufficient to support three times the present pulping capacity of mills in the state, depending upon the pulping process used.

During the past few years, there has been increasing use of sawmill residues by pulpmills in the central states. In 1964 Illinois pulpmills reported using more than 50 thousand tons of saw and planing mill residues. Slabs and edgings from the larger sawmills in Illinois and adjacent states are sufficient to provide more than double this amount to Illinois pulpmills.

Adequacy of Transport Facilities

The third most important factor to be considered in evaluating expansion of pulp and paper manufacture in Illinois is the adequacy of transport facilities. The cost of shipping finished products to market is an important factor affecting the location of any integrated pulp and paper mill. The cost of procuring pulpwood is also important, especially where shipping charges must be paid by the mill (rail costs on purchased pulpwood) or included in the delivered price of pulpwood (trucked pulpwood). Availability and efficiency of the transportation system thus has a direct bearing on prospects for expanding pulp and paper manufacture.

Pulp and paper products manufactured in Illinois (primarily printing papers, wrapping paper, paperboard, fiberboard, building paper, and insulating materials) are shipped to all parts of the nation. Heaviest shipments are to the central and lake states and to the upper south.¹ Building papers and roofing felts, together with paperboards and fiberboards, comprised over 90 percent of the total tonnage shipped from Illinois in 1961. Building paper and roofing materials were the most important products shipped. Although shipment by truck is important, especially on shorter hauls, about 82 percent of all pulp and paper products shipped from Illinois in 1961 moved by rail.

¹ Interstate Commerce Commission, Bureau of Transport Economics and Statistics, *Carload Waybill Statistics, 1961*, State-to-State Distribution of Manufactures and Miscellaneous and Forwarder Traffic (C. L.), Traffic and Revenue, Washington, D. C., February 1963.

In the central states average maximum hauling distance for pulpwood is about 100 miles. In Illinois the average haul to pulpmills is only about 30 miles. In both cases nearly all pulpwood moves by truck. The availability and condition of roads, especially rural roads, are thus important considerations in the movement of pulpwood. Hauling costs in the central states commonly represent from 12 to 35 percent of the delivered price of pulpwood.¹ These costs are high enough to influence the decision to produce pulpwood in a given area or timber stand. As noted earlier, good data on costs of hauling pulpwood by truck in Illinois are not available. Pulpwood producers estimated their hauling costs to be from \$1.00 to \$3.00 per 168-cubic-foot cord (average \$2.80). Assuming the average price paid for delivered pulpwood to be about \$13 per cord, hauling costs thus amount to over 20 percent of the delivered price.

Of all of the resources available in Illinois for manufacturing and commerce, transportation facilities are probably the most attractive. By most standards the transportation system of Illinois is one of the finest in the world. Illinois has long been recognized as the crossroads of the nation, a central point for America's railway, highway, airline, and pipeline systems. In addition the state lies between the two great waterways of the nation, the Great Lakes and the Mississippi-Ohio river systems. Thus situated, Illinois' transportation system effectively binds the state together and provides effective connections between all Illinois locations and the rest of the nation and, to a considerable extent, the rest of the world.

The geographical location of the state has further significance for pulp and paper as well as other manufacture. Illinois is located at the western end of the huge manufacturing complex which extends into the northeastern part of the nation. It therefore functions as a first point of assembly for raw materials originating in the northwestern, western, and southwestern regions of the country. Also, Illinois is the major manufacturing state nearest to a market area comprising one-half of the nation.

Illinois occupies an advantageous position as far as the U. S. freight rate structure is concerned. Because of its central location within the Uniform Classification Rate Territory, there is a more even distribution

¹ Manthy, R. S., and James, L. M., *Marketing Pulpwood in Selected Areas of the North Central Region*, Michigan Agr. Exp. Sta. Res. Bul. 6, North Central Reg. Res. Pub. 156, 1964.

of freight class rates to all points east of the Rocky Mountains than locations near the margins of the territory. Also, because freight shipped from beyond the Rocky Mountains moves at commodity rates, Illinois is in essentially as good a competitive position, as far as trans-Rockies shipments are concerned, as any area in the eastern United States. Furthermore, because Illinois lies between the two greatest inland waterways of the nation, it receives the benefit, through lowered land transportation charges, of the competition between the land and water systems. Finally, the historic interline competition between the nation's two greatest railroad centers, Chicago and St. Louis, has resulted in special rate advantages to Illinois points for many commodities.

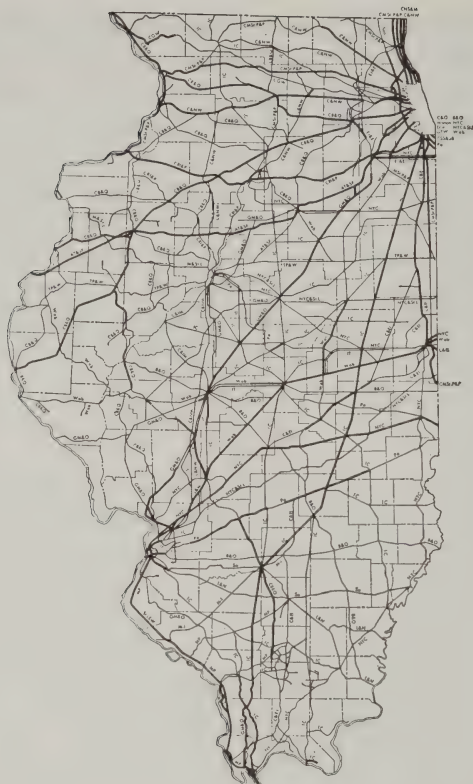
Railroads

Present mileage of railroad lines in Illinois is 11,316 miles.¹ Only one county of the state's 102 counties is without a railroad line. Thirty Class I line-haul railroad companies; 37 Class II terminal, switching, transfer, and industrial railroad companies; and 2 electric interurban lines operate in the state. Because operating lines use standardized equipment and practices, it is physically and economically feasible to exchange rolling stock between systems, making Illinois railroad mileage an integral part of the larger continental railroad system. Fig. 17 shows the railroad network in the state.

Illinois' basic railroad system may be described briefly as follows, considering primarily the heavy-duty lines, i.e., lines with more than one track and with automatic train control and signaling systems: The original land grant lines radiate out from Chicago to the north, northwest, west, and southwest; many of these lines provide transcontinental service. Railroad lines entering the southern sector of the state serve the north-south Mississippi routeway. The major pattern is completed with nine lines entering Chicago from the east.

East St. Louis in southwestern Illinois is the center of another system of railroads providing service to the east, south, and southwest. In addition, East St. Louis is the terminal for a number of coal-hauling lines linking the city to Illinois coal fields. A third basic railroad pattern is associated with Peoria in west-central Illinois, a focal point for 13 different railroad lines. A complete statewide network of north-

¹ State of Illinois, Division of Industrial Planning and Development, *Atlas of Illinois Resources*, Section 4, "Transportation," June 1960.



Common carrier railroads serving Illinois.
(Fig. 17)

south and east-west connecting lines provides the connections between the three basic radial railroad patterns.

The close network of railroad lines in Illinois gives shippers special advantages. No shipping point is very far away from one of the 2,500 stations scattered over the state. Because the railroads carry heavy tonnages, there are interchange facilities at about 90 percent of the railroad crossing points. The movement of large amounts of freight has required the scheduling of many trains and installation of automated freight yards. Special services and terminal facilities are available along with cars for special purposes. It is estimated that almost all points on the mainland of the United States, except those on the west coast, are within six days or less of Illinois by scheduled freight. It is not likely that availability of railway facilities could ever be a limiting factor in expansion of pulp and paper manufacture in Illinois.

Highways and roads

Illinois has 102,348 miles of roads consisting of interstate highways, state highways, county highways, and township and district roads. Interstate and state highways are state-administered; both receive varying proportions of federal aid. County highways are county-administered and receive state aid; about one-half of this mileage also receives federal aid. Fig. 18 shows the primary highway road net over the state as of 1959.

The interstate highway system, when it is completed, will cover 1,608 miles interconnecting all of the heavily populated areas of the state and joining Illinois to all of the commercial and industrial centers of the nation via limited-access, high-capacity highways. To date about 200 to 300 miles of this basic framework of the primary highway system of the state is completed. The rest of the primary highway system



Primary highways in Illinois. (Fig. 18)

totals 10,630 miles; 95 percent of this is paved. Most of this road system is two-laned, although multilaned roads are common on approaches to the larger cities. This tremendous mileage enables the operation of more than 1,400 trucking companies employing 10 or more vehicles each. There are 1,700 points within the state served by truck and very few areas in the entire nation which are more than five delivery days away.

The secondary and local rural roads of the state consist of 18,295 miles of county highways and 73,321 miles of township and district roads. Most of the county highways have received low-type surfacing, including bituminous, gravel, stone, or oiled earth treatment. The county highway network serves farm-to-market traffic and is also a feeder road system to the primary highways. This is particularly important in a state like Illinois, where pulpwood supplies are to be found primarily on numerous farm woodlots.

Water transport facilities

To date very little manufactured pulp and paper or pulpwood has been transported by water in Illinois, although movement of wood pulp across the Great Lakes has been common for many years. However, a well-developed water transportation system is available to Illinois manufacturers. Ports in the Chicago area provide access to all of the Great Lakes ports and all of the ocean ports via the St. Lawrence Seaway. Mississippi frontage covers 581 miles, the Ohio River frontage 113 miles, and the Illinois Waterway 330 miles. Fig. 19 shows these waterway facilities as of 1959. The Illinois Waterway, which consists of the Illinois River, the Chicago Sanitary and Ship Canal, the Calumet-Sag Channel, and the Chicago River, is of particular significance because it provides a direct, all-water connection between the two major continental waterway systems. This system might make possible the establishment of pulp and paper mills in the northern and northeastern parts of the state, where water is plentiful but pulpwood is not. Pulpwood could probably be moved considerable distances by barge using this and the other waterways available to the state at relatively low rates.

Barges operating on Illinois waterways vary in capacity from 800 to 3,000 tons. They are of various designs to carry dry bulk, liquid bulk, or general cargo. Special barges are available for particular products. There is no reason to believe that pulpwood or wood chips could not be moved cheaply and efficiently by barge.



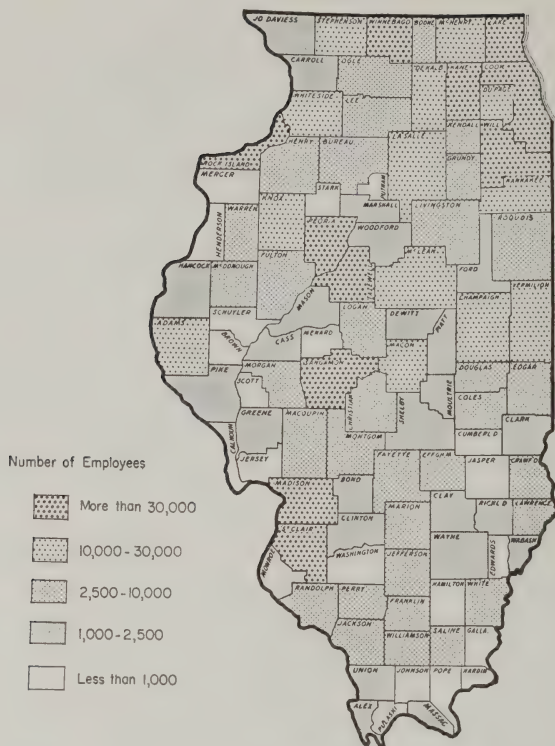
Illinois waterway transportation facilities. (Fig. 19)

Adequacy of Labor Supply

Availability of labor

Labor requirements for greatly expanded pulp and paper manufacture and pulpwood marketing in Illinois could be met without difficulty. Illinois ranks fourth in population among states, this population being about evenly divided between metropolitan and nonmetropolitan areas. In population, labor force, and employment, Illinois parallels the national growth pattern.

As in other areas of the country, Illinois' population has been shifting from rural to urban areas because of reduced manpower needs in farming, declining employment in farming and, in some counties, declining manufacturing. Metropolitan expansion has occurred primarily in the northern, north-central, and northeastern counties of the state. Population declines have occurred primarily in the southern one-third



Nonagricultural employment in Illinois by counties.
(Fig. 20)

of the state. These shifts in population are indicative of the willingness of people in the labor force to move to areas where employment opportunities are expanding. At the same time many communities with labor surpluses, particularly in southern Illinois, could provide attractive locations for new industries. Some of these areas, especially those which are more heavily forested, might be particularly well suited for expanded pulpwood operations and pulp and paper manufacture.

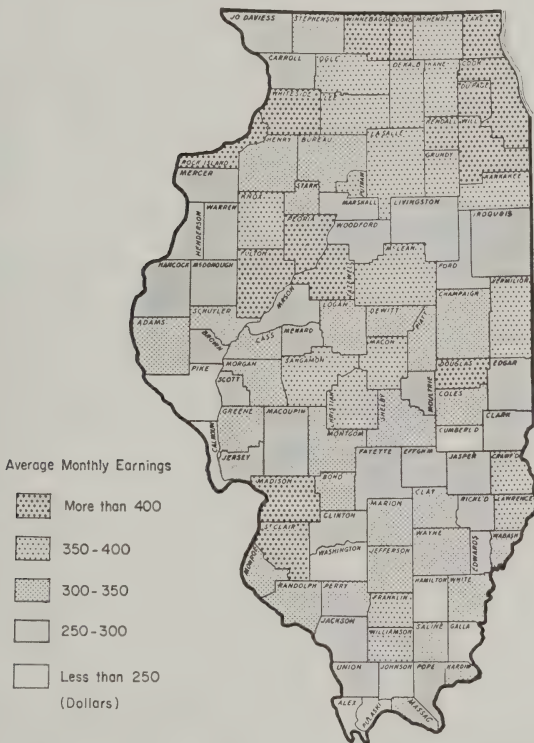
Whereas labor appears to be more fully utilized in the metropolitan areas of the state, all areas are capable of rapid expansion in meeting new demands for labor. Studies in Illinois have shown that local population is usually capable of a higher rate of labor force participation; what cannot be supplied by local participation can usually be met through in-migration of experienced workers.¹ Fig. 20 shows non-agricultural employment by counties as of March 1960.

¹ University of Illinois, Institute of Labor and Industrial Relations, *Atlas of Illinois Resources*, Section 5, "Manpower Resources," May 1963.

Wages and salaries of nonfarm workers in private industry in Illinois are quite variable. Generally, higher average salaries and wages are found where industrialization and urbanization are important. Fig. 21 shows estimated average monthly earnings by county for the first quarter of 1960. These averages do not apply to all employment in each county, and they only approximately represent the monthly earnings of the typical industrial worker. Wages paid to woods workers are not generally available. However, it is believed that woods labor can be obtained for the minimum wage of \$1.25 per hour.

Labor relations in Illinois

The density of unionization in Illinois is greater than in many other states; in 1953 Illinois ranked about eighth in density of union membership. In terms of total union membership, Illinois ranks fourth in



Estimated average monthly wage and salary rates of industrial workers in Illinois for the first quarter of 1960. (Fig. 21)

the nation, with 1,385,000 members. This was about 40 percent of all nonfarm employees in the state. Of these, about 72 percent were affiliated with AFL unions, about 19 percent with CIO unions, and 9 percent with independent unions, mostly railroad and coal-mining unions.

Labor relations have been relatively stable since World War II. Work stoppages have been about at the average for the nation as a whole. In 1958, man-hours lost through work stoppages in Illinois were less than one-fourth of 1 percent of all man-hours worked. According to recent studies conducted by the Institute of Labor and Industrial Relations of the University of Illinois involving manufacturing firms in the Decatur, East St. Louis, and Carbondale-Herrin areas, most of the unions involved are industrial-type organizations bargaining for all production of hourly paid workers on a plant basis. Multi-company agreements are uncommon in manufacturing except in basic steel, meat-packing, and glass. On the other hand, multicompany agreements are much more common in the construction, trucking, mining, trade, and service industries.

Disputes and grievances have generally been settled without recourse to outside mediators or conciliators. During the past two years it has been possible to negotiate new contracts without work stoppages. Furthermore, the parties state that threats of work stoppage have not been used very often. The typical labor-management relationship appears to be a reasonably satisfactory one.

There are about 45 laws in the Illinois statutes dealing with labor matters. The more important of these, together with the services provided by the Illinois Department of Labor, are shown in Appendix A.

Availability of Electricity and Other Fuels for Power

All of the pulping processes make use of steam for heating purposes and electricity for operating machinery. Steam requirements range from 2,500 to 7,500 pounds per ton of chemical pulp and 2,000 to 4,000 pounds per ton of semichemical pulp. Electricity requirements average about 250 kilowatt-hours per ton for the chemical pulps and range from 400 to 600 kilowatt-hours per ton for semichemical pulps to 900 to 1,800 kilowatt-hours per ton for groundwood pulps.

Although not nearly as important in pulp plant location decisions as the other input factors already discussed, fuel for steam generation and heat, and electricity for power, should be available at reasonable cost if new pulping facilities are to be encouraged.

Illinois is both a large producer and consumer of nonsolid mineral

fuels. As a consequence, the state has a well-developed pipeline system for transporting these fuels. Altogether there are 35,000 miles of line, including 3,600 miles of gathering lines for moving crude oil and natural gas from wells to storage facilities within the producing fields; about 4,500 miles of crude oil trunk lines carrying crude oil from field storage to refineries; some 2,200 miles of refined product trunk lines, transporting refined products to consuming centers; and finally, over 24,000 miles of gas pipelines which directly connect producing fields and their markets. Gathering lines, the older crude trunk lines, and the refined products lines are usually less than 10 inches in diameter. However, the newer trunk lines are about 20 inches in diameter; gas trunk lines are normally between 20 and 30 inches in diameter.

There are three principal pipeline systems within the state. One is associated with the producing area of southern Illinois and consists of a widespread network of gathering lines and crude oil trunk lines serving the refineries of the Wood River District and the Wabash Valley. A second system originates in the producing areas of Texas, Louisiana, Oklahoma, and Kansas and helps meet the demand for non-solid mineral fuels in Illinois. The third system supplies areas to the north and east; most of the west-east lines in the south-central part of the state are "bridge" lines built during World War II.

Many of the through lines can be and have been tapped to supply local power, treating, and industrial demands. It is most likely that nonsolid mineral fuels could be made available at reasonable cost at almost any proposed pulping plant site.

Fuel and power rates for Illinois for various sizes of industrial users compare fairly well with such rates elsewhere. Only in the east south central (Kentucky, Tennessee, Alabama, Mississippi) and west south central (Arkansas, Louisiana, Oklahoma, Texas) regions are fuel and power rates lower (see Table 18). The locations, types of ownership, names of controlling utilities, and generating capacities of 125 power plants in Illinois are shown in Appendix B.

Possibilities for Expanded Hardwood Pulp Manufacture in Illinois

Comparative pulping costs

Earlier sections of this report have considered availability of the major resources needed to manufacture pulp. Physical resource availability, of course, is a prime requirement, but the costs of these re-

sources and, more important, the competitive cost position of Illinois relative to other pulp manufacturing states are equally important.

It is possible to describe in very general terms the cost of building new pulping facilities. At best such plants are expensive. The total cost of building new pulping plants depends mainly on the size of the mill. According to information provided by the Forest Products Laboratory, the size of a chemical pulpmill that can be operated economically depends upon the availability, quality, and cost of raw materials; proximity to markets; and the type of product manufactured. Mills with capacities as low as 50 to 100 tons per day can be built and operated economically if all of these factors are favorable, and particularly if some specialty pulp product is to be manufactured.

On the other hand, where raw material costs are higher, or where markets are not close, and particularly if the manufactured product (Kraft wrapping paper or paperboard, for instance) is a highly competitive one, economical mills must be larger in order to utilize larger and more efficient equipment. Usually such mills would need to have a minimum daily capacity of around 300 tons.

Pulpmill construction costs vary widely and have risen greatly in recent years. It costs from \$40,000 to \$50,000 per ton of daily capacity to build a groundwood, chemimechanical, or a semichemical pulpmill (without equipment for chemical recovery). The cost of building a semichemical mill with an independent chemical recovery system would cost about twice this much. The probable cost of a Kraft or sulfite mill would range from \$70,000 to \$100,000 or more per ton per day.

Whether or not the construction of new pulpmills requiring large capital expenditures would be justified in Illinois also depends on Illinois' competitive cost position relative to neighboring pulp-producing regions. Comparing pulp-making costs among competitive producing regions is difficult because the necessary cost data are not readily available. However, it is possible to compare costs in a very general way using published data on regional wood, transportation, labor, and fuel costs compiled by the U. S. Bureau of the Census and other public agencies. These costs can be weighted according to their relative importance in the pulp-making process, and indexes computed which represent regional over-all cost levels. A comparison of these indexes provides some idea of relative pulping costs among regions.

Using the method developed by Perry R. Hagenstein¹ to determine

¹ Hagenstein, P. R., "Decision Factors in Determining Pulpwood Locations," Northeastern Forest Experiment Station, U. S. Forest Service. Paper presented at Forest Policy Forum, American Pulpwood Association, annual meeting, February 23, 1964.

regional comparative cost advantage, Table 17 shows regional cost indexes applying to the four most important factors affecting the cost of manufacturing pulp. Values greater than 100 represent costs over the average level for all of the regions; values less than 100 represent less than average costs. Illinois is included in the east north central region, along with Ohio, Indiana, Michigan, and Wisconsin. The high index of wood cost for the north central region (137) reflects the high prices paid for aspen, spruce, balsam fir, hemlock, and pine in Michigan and Wisconsin mills. While much cheaper hardwoods are used in Ohio, Indiana, and Illinois mills, labor, fuel, and transportation costs for the east north central region compare fairly well with the other pulp manufacturing regions.

Table 18 shows combined regional cost indexes for production and shipment of wood pulp. In general a given producing region will have an over-all cost advantage over most other producing regions when viewed also as a consuming region; the Pacific, mountain, east south central, south Atlantic, and west north central regions are good examples. Other producing regions, however, are subject to cost competition from neighboring regions. For example, it costs less to produce and transport pulp products to New England from mills in the south Atlantic and east south central regions than it does to produce these products in New England itself. Producers in the east north central region (which includes Illinois) have somewhat higher costs than producers in the east south central, south Atlantic, and west north central regions and thus appear subject to competition even when selling within their own region. However, as noted earlier, the over-all cost index which applies to Illinois (93 in Table 18) is heavily weighted by the high cost of pulpwood in Michigan and Wisconsin. Costs of pulp production and shipment in Illinois using hardwoods are thus undoubtedly lower than the regional cost index suggests. Using wood costs for the east north central region which compares to Illinois pulpwood prices would give Illinois a regional cost index of a much lower range. It is most likely that Illinois competes strongly with mills in other regions for markets in the midwest and middle Atlantic states where much of the nation's population is located. Illinois' competitive position is probably stronger still when production of insulating, fiberboards, and roofing felts instead of all paper products is considered. It will be recalled that hardwood pulpwood is well suited for these products and is being used in increasing amounts in all of the central states.

Table 17. — Regional Cost Indexes of Four Factors Affecting Pulp Manufacturing Costs

Region ^a	Wood ^b	Labor ^c	Fuel ^d	New Eng.	Product transportation cost to ^e							Moun- tain	Pa- cific
					Mid. Atl.	East north cen.	West north cen.	South Atl.	East south cen.	West south cen.			
New England.....	128	96	138	33	66	105	125	105	125	205	220	265	
Middle Atlantic.....	138	96	118	66	33	66	105	66	105	125	205	220	
East north central.....	137	104	94	105	66	33	66	105	105	125	205	220	
West north central.....	108	90	93	125	105	66	33	105	105	105	125	205	
South Atlantic.....	91	97	103	105	66	105	105	33	66	105	125	205	
East south central.....	83	100	75	125	105	105	105	66	33	66	105	205	
West south central.....	89	105	70	205	125	125	105	105	66	33	105	205	
Mountain.....	85*	124	97	220	205	205	125	125	105	105	33	105	
Pacific.....	92*	108	129	265	220	220	205	205	205	205	105	33	

^a U. S. Bureau of the Census regions.^b U. S. Bureau of the Census, 1954 Census of Manufacturers.^c U. S. Bureau of the Census, 1953 Census of Manufacturers.^d Edison Electric Institute, Statistical Yearbook of the Electric Utility Industry for 1961.^e U. S. Interstate Commerce Commission, Waybill Sample 1961, Railroad Freight Rates for Various Classes of Paper.

* Estimated.

Table 18. — Combined Regional Cost Indexes for Production and Shipment of Wood Pulp^a

Producing regions ^b	Consuming regions ^b								
	New Eng.	Mid. Atl.	East north cen.	West north cen.	South Atl.	East south cen.	West south cen.	Mountain	Pacific
New England.....	93	100	109	113	109	113	132	135	145
Middle Atlantic.....	103	95	103	111	103	111	116	134	138
East north central.....	109	100	93	100	109	109	114	132	136
West north central.....	99	94	85	78	94	94	94	99	117
South Atlantic.....	88	79	88	88	72	79	88	93	111
East south central.....	87	82	82	82	73	66	73	82	105
West south central.....	108	90	90	85	85	76	69	85	108
Mountain.....	115	111	111	93	93	88	88	72	88
Pacific.....	130	119	119	116	116	116	116	93	76

^a Total cost indexes for wood, labor, fuel, and transportation, weighted by cost substitution rates discussed on page 26 as follows:

Wood.....	1.00	Labor.....	0.28
Transportation.....	0.50	Electricity.....	0.23

^b U. S. Bureau of the Census regions.

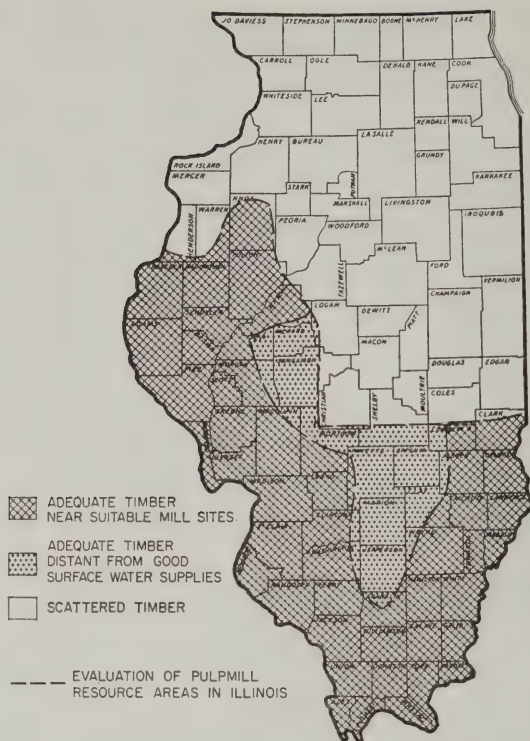
Note: Table based on data reported by Perry R. Hagenstein. See page 26.

Potential pulpwood supply areas and pulpmill sites

It is possible to delineate in a general way the more promising areas for pulp and paper plant locations based primarily on availability of pulpwood and water supplies (Fig. 22).

If new pulping plants are to operate on roundwood pulpwood, it is immediately apparent that almost one-half of the state north and east of a line running southeast from Carroll County to Montgomery County and then east to Edgar County can be eliminated from further consideration, even though water is abundant in this area. The mills presently operating in this region use wood waste from secondary wood-using plants or purchase market pulp.

Because it becomes expensive to transport pulpwood more than about 50 or 60 miles by truck, it is unlikely that new mills established along the Wabash, Ohio, or Mississippi, where water flow is large enough for all pulping processes, could afford to draw pulpwood supplies from counties much beyond the dotted peripheral line shown in Fig. 22. These supplies could, in some cases, be augmented with timber from across the river in the adjoining states of Kentucky, Missouri, and Iowa. Although water supplies would be adequate, pulpwood supplies would not be in those Mississippi River counties north of Hancock County in western Illinois.



Evaluation of pulp mill resource areas in Illinois.
(Fig. 22)

There does not appear to be enough pulpwood along the Illinois River above Fulton and Mason counties to support new mills, although water flows are probably sufficient, especially if chemical effluents were treated or if groundwood or exploded wood-pulping processes were employed.

Pulpwood supplies are also insufficient in the counties through which the Rock River flows, although enough water is available for all of the pulping processes, particularly if mills were to install waste water treatment systems. A mill located along the Mississippi somewhere north of its confluence with the Illinois River is a possibility. Pulpwood supplies could be drawn from such well-forested counties as Adams, Pike, Hancock, Schuyler, Knox, and Fulton.

Other than the Illinois and Rock rivers, it is not likely that the state's other internal streams could be depended on to furnish adequate surface water for pulping purposes. However, pulping based on pro-

cesses which have lower water requirements, like the exploded wood or groundwood processes, remain a possibility in the counties bordering the Kaskaskia River. As seen in Fig. 11, the Kaskaskia River Valley is an excellent source of ground water because of the presence of deep deposits of glacial sand and gravel. A mill or mills manufacturing pulp by one of the processes with lower water requirements could draw pulpwood from either side of the Kaskaskia River from such heavily forested counties as Shelby, Fayette, Wayne, Jefferson, St. Clair, as well as from Madison, Bond, Clinton, Washington, Marion, Clay, and Effingham counties.

According to Table 16, pulpwood supplies in the claypan region could support a daily pulping capacity of up to 1,525 tons if the groundwood or exploded wood processes were used, up to 880 tons if a Kraft or sulfate process were used, and up to 1,200 tons if a semichemical process were used. Because surface water is limited within the claypan region, new sulfate or semichemical pulpmills would have to utilize sites along the Mississippi River in the west or the Wabash River in the east. However, if a mill dependent on groundwater were built anywhere along the Kaskaskia River, only the exploded wood or groundwood processes could be employed.

Summary and Conclusions

The timber resources of Illinois presently make only a token contribution to the state's income from all sources. However, the potential for a much larger contribution is there. Although there are a number of interrelated reasons for this state of affairs, the principal ones are that Illinois' timber stands, through past practices, are characterized by understocking, low-quality trees, and relatively low growth rates. Furthermore, the practice of forest management on privately owned timberlands, which could remedy this situation in time, has only recently been gaining some acceptance. As a result, Illinois manufacturers still satisfy most of their wood and wood product raw material requirements by imports from other states, at costs which may be much higher than they might be if more of this need could be supplied from within the state.

Although native timber stands do not represent an important source of high-grade timber, they are a good source of hardwood pulpwood which has a growing market both inside and outside the state. Expansion of pulp manufacture in Illinois would encourage the removal of

much of what is presently viewed as poor growing stock; cost of the removal would be covered and additional returns would accrue to forest owners. Removal of poor growing stock, together with the adoption of better forest practices on the remaining timberlands, would result in the production of timber better suited to Illinois' industrial needs.

The potential market for pulp and paper products is bright. All pulp and paper consumption estimates suggests that there will be great increases over present levels. The U. S. Forest Service, in its new appraisal of the forest situation, estimates that consumption of paper and board and consumption of pulp may be as high as 69 million tons and 52 million tons, respectively, including imports by 1980.

The central states, including Illinois, account for somewhat less than 25 percent of the nation's paper and board production. Whereas production in 1960 was about 8 million tons, consumption was estimated to have been about 10 million tons, leaving the region deficit by about 2 million tons. This deficit has been met by annual paper and paper-board shipments into the region from the paper-surplus regions of the west, south, and northeast.

Increased consumption of pulp products will require increased production and very likely some increase in imports of both pulp and paper. The central states should share in these expected increases. It is estimated that almost 8 million tons of pulp will be needed annually for paper and paperboard manufacture in the central states by 1970. If the central states become more important in the manufacture of insulating boards and hardboards, pulp requirements will be even higher. At present the region does not provide for more than one-half of its pulp needs. If the pulp-producing capacity of the region grows only enough to maintain its present position over the next five years, production of all pulp grades would be 4 million tons annually by 1970. This is one-third more than production in 1962, but still only half of the volume required to satisfy anticipated needs.

The potential markets for pulp products, and the pulpwood from which they are made, are thus substantial. These markets will be even more important if the trend toward greater use of pulp and paper products by industry and a growing population continues to rise.

This study considered the resources which are believed to be important in pulpmill location decisions and their relative weights. These are: pulpwood supply (1.0), transportation facilities (0.50), labor availability (0.28), electricity and nonsolid mineral fuels facilities (0.23), state and local taxes (0.02), forest land acquisition (0.002),

local financing concessions (0.001), and industrial site consideration (0.0004). Water is of major importance, but is not subject to this rating system. Only water, pulpwood, transportation, and labor resources were dealt with in this analysis. The other resources were ignored because only general, not specific, mill site possibilities were considered.

Illinois is a well-watered state. Water supplies and rates of flow appear adequate for most pulping processes along the Mississippi, Ohio, Wabash, and Illinois rivers. Water flows also appear adequate for some pulpmill development along the lower portions of the Rock and Kankakee rivers, although pulpwood supplies there are inadequate.

The very substantial surplus of low-quality timber suitable for pulpwood but not for high-quality lumber or veneer products could by itself sustain an expanded pulp and paper industry for some time in the claypan and southern regions of Illinois. Estimates of desirable cut suggest that over 9 million cords in the claypan region and almost 7 million cords in the southern region could be made available annually as pulpwood. These volumes appear sufficient to support daily pulping capacities of about 800 to 1,525 tons in the claypan region, depending on the pulping process being considered. In the southern region the estimated daily capacities are from 570 to 1,095 tons.

Illinois has one of the finest transportation networks to be found anywhere in the United States. It is not likely that availability of transportation facilities could be a limiting factor in the expansion of pulp and paper manufacture in Illinois.

The study shows that labor needs for greatly expanded pulp and paper manufacture and pulpwood marketing could be met without difficulty.

It was found most likely that nonsolid mineral fuels, coal, or electricity could be made available at reasonable cost at almost any conceivable pulping plant site.

A comparison of over-all costs of pulp and paper production and shipment among the important manufacturing regions of the United States suggests that Illinois competes strongly with mills in other regions for markets in the midwest and middle Atlantic states. Illinois' competitive position is enhanced when production of insulating boards, hardboards, and roofing felts is considered instead of all paper and board products. It is noteworthy that hardwood pulpwood is highly suited to these products and is being used in increasing amounts in all of the central states.

In general the more promising sites for new pulpmills are along the big rivers — the Mississippi, Ohio, and Wabash. Water flows in these rivers are sufficient for all processes and large daily pulp production. Because it is expensive to haul pulpwood more than 50 or 60 miles by truck, it is unlikely that new mills established along the big rivers can afford to draw pulpwood supplies from counties beyond the line shown in Fig. 22. Supplies for such mills could, in some cases, be augmented from pulpwood sources across the rivers in the adjoining states of Kentucky, Missouri, and Iowa.

There does not appear to be enough pulpwood to support a new mill or mills along the Illinois River above Fulton and Mason counties, although water flows are sufficient, especially if chemical effluents were treated or the groundwood or exploded wood processes were employed.

Pulpwood is also insufficient in the counties through which the Rock and Kankakee rivers flow, although enough water is available.

A mill located along the Mississippi somewhere north of its confluence with the Illinois River is a possibility. Pulpwood supplies could be drawn from such relatively well-forested counties as Adams, Pike, Hancock, Schuyler, Knox, and Fulton.

Other than the Illinois and Rock rivers, it is unlikely that any of the state's internal streams could be depended upon to furnish a steady supply of surface water sufficient for pulping purposes unless reservoirs were built at or near pulpmill sites. However, pulping based on the groundwood or exploded wood processes remains a possibility in the counties bordering the Kaskaskia River.

Pulpwood supplies in the claypan region could support a daily pulping capacity of up to 1,525 tons if the groundwood or exploded wood processes were used, up to 880 tons if the Kraft or sulfate processes were used, and up to 1,200 tons if a semichemical process were used. Pulpwood supplies in the southern region appear adequate for support of a daily output of 1,090 tons of groundwood or exploded wood pulp, 620 tons of sulfate pulp, or 850 tons of semichemical pulp.

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Appendix A

Illinois Labor Laws and Services¹

Unemployment compensation

An unemployment compensation act provides for partial replacement of wages lost by individuals because of lack of work opportunities. Individuals must meet specific eligibility requirements and must have worked, in the recent past, for employers liable for payment of contributions. The law covers employers of four or more workers. Excluded from coverage are agricultural labor, public employees, domestic workers, and employees of certain nonprofit institutions. Employers presently exempt may elect coverage by filing with the Director of the Department of Labor.

Workmen's compensation

The Workmen's Compensation Act and the Occupational Diseases Act provide for specified payments to employees injured or sustaining an occupational disease in the course of employment. These laws require covered employers, and those electing coverage, to furnish financial guarantees when self-insured or to insure their liability with some authorized insurance carrier. A separate law entitled Workmen's Compensation or Occupational Diseases Insurance for Rejected Employers provides that if an employer entitled to insurance has been rejected by three insurance carriers, the commission will designate a carrier who is then obligated to issue a policy to the employer; losses incurred on such policies are equally distributed among all carriers. The acts cover all extra-hazardous employments and also state and local employments. Employers not electing coverage are subject to common law or statutory tort liability and in such actions are barred from asserting the common law defenses of assumption of risk, fellow servant negligence, and contributory negligence. Where employment is governed by federal legislation — the Federal Employer's Liability Act, the Jones Act, or the Longshoremen's and Harbor Worker's Act — the employee has no remedy under the State Workmen's Compensation Act.

Health and safety legislation

The Illinois Department of Labor, through its Division of Safety Inspection and Education, is empowered to visit and inspect as often as practicable the factories, mercantile establishments, mills, workshops, and all other industrial and commercial establishments in the state to promote safety practices. The Health and Safety Act requires all employers to provide reasonable protection to the lives, health, and safety of all employed persons and provides the rules to be followed. Under the Radiation Installation Act, every operator of a radiation installation is required to register with the Department of Public Health.

¹ University of Illinois, Institute of Labor and Industrial Relations, "Atlas of Illinois Resources," Section 5, Manpower Resources, May 1963.

Assignment and garnishment of wages

In Illinois, 85 percent of gross wages are exempt from garnishment, with a minimum exception of \$45 per week and a maximum of \$200 per week. No wage garnishment can be obtained on a judgment entered by confession. Furthermore, seizure of wages without due notice and normal prosecution of a suit is prohibited. Demand on an employer for wages of an employee, by virtue of a wage assignment, cannot be made until there has been a default in payment in excess of 60 days, and the assignment cannot run for more than 30 days without the successful prosecution of a suit.

Fair employment practices legislation

A Fair Employment Practices Act was passed in 1961. This act makes it an unfair practice to discriminate because of race, color, religion, national origin or ancestry in hiring, terms of employment, selection of persons for apprenticeship, and tenure. This act applies to employers of 50 or more workers and also to employment agencies and labor organizations. A Fair Employment Practice Commission is empowered to hold hearings based on complaints and to issue cease and desist orders.

Labor relations laws

Illinois is a common-law state in the area of labor relations law. The courts, not the General Assembly, have established the standards of conduct for both labor unions and employers. There are five Illinois statutes pertaining to labor relations.

1. Chapter 48, Section 2a, of the Illinois Revised Statutes prohibits the issuance of an injunction or restraining order against peaceful work stoppages or peaceful picketing "in any case involving or growing out of a dispute concerning terms or conditions of employment."

2. Chapter 48, Section 2b, declares it to be contrary to public policy for an employer to exact from an employee, as a condition of employment, a pledge not to join a union. There is judicial recognition of the right of workers to organize, on the premise that every citizen may pursue his calling as he thinks best. By the same token, no Illinois statute or court decision directly requires that an employer recognize or negotiate with a union.

3. Chapter 48, Section 2c, requires that an employer advertising for workers during a strike or lockout must state in the advertisement that there is a strike or lockout in progress. Furthermore, the law prohibits detectives from inciting strikes, fomenting labor troubles, or breaking unions.

4. Chapter 38, Section 242-246, makes it unlawful for any union official or any other person who claims to represent a group of workers to try to extort money from an employer as a condition for settling a labor dispute. Union officials may not collect fines assessed against employers by labor organizations. Finally, the criminal code's definition of illegal conspiracies includes a ban on circulars or edicts meant to encourage boycotts or black lists that are illegal in nature.

5. Chapter 10, Sections 19-30, provides for mediation of grievances and fact finding under the auspices of the Department of Labor. This service is available in labor disputes involving 25 or more workers and their employers, either at the request of the parties concerned or on the initiative of the department.

Civil suits against labor unions are not usually permissible except that a group of members, usually the union's officers, may be sued on behalf of the entire union membership, provided, *inter alia*, that it is established that the entire membership shares a "community of interest." Or it may be possible to bring damage actions in conjunction with equitable proceedings.

Most employer-employee relationships in Illinois are also subject to federal labor relations legislation. The U. S. Supreme Court has held that the jurisdictional authority of the National Labor Relations Board is coextensive with the reach of Congress under the commerce power. When the Board declines to take jurisdiction, it may delegate certain of its powers to its regional officers and the states may take action under Section 701 of the Landrum-Griffin Bill, 72 Stat. 519.

Appendix B

Electric Plant and Ownership List

Plant No.	Plant name	Megawatt capacity and type	Utility abbreviations	Type owner	Utilities
1	Abbott	30.0 St.	UNIL	State	University of Illinois
2	Decatur	16.0 St.	STMF	Ind.	A. E. Staley Mfg. Co.
3	Altamont	1.8 I.C.	ALTM	Mun.	Altamont
4	Alton	1.0 St.	OWIG	Ind.	Owens-Illinois Glass Co.
5	Alton	1.0 St.	LAST	Ind.	Laclede Steel Co.
6	Alton	23.2 St.	ALBB	Ind.	Alton Box Board Co.
7	Aluminum Co. of America	21.5 St.	ALCA	Ind.	Aluminum Co. of America
8	Argo	30.7 St.	CORC	Ind.	Corn Products Refinery Co.
9	Argonne	5.0 Nu.	USAT	Fed.	U. S. Atomic Energy Comm.
10	Aurora	48.0 St.	COEC	Priv.	Commonwealth Edison Co.
11	Bloomington	8.5 St.	ILPC	Priv.	Illinois Power Co.
12	Bloomington	6.1 I.C.	BLOM	Mun.	Bloomington
13	Breese	2.8 St.	BREE	Mun.	Breese
14	Bushnell	.9 I.C.	BREE	Mun.	Breese
15	Cahokia	4.1 I.C.	BUSH	Mun.	Bushnell
16	Calumet	800.0 St.	UNEC	Priv.	Union Electric Co.
17	Carlyle	294.5 St.	COEC	Priv.	Commonwealth Edison Co.
18	Carmi	4.5 St.	CARL	Mun.	Carlyle
19	Casey	1.1 I.C.	CARM	Mun.	Carlyle
20	Champaign	7.4 I.C.	CASE	Mun.	Carmi
21	Crawford	4.4 I.C.	CASE	Mun.	Casey
22	Danville	3.0 St.	ILPC	Priv.	Illinois Power Co.
23	Dayton	740.0 St.	COEC	Priv.	Commonwealth Edison Co.
24	Decatur	15.3 St.	ILPC	Priv.	Illinois Power Co.
25	Dixon	3.7 Hy.	NOCH	Priv.	North Counties Hydro-Electric Co.
26		3.5 St.	ILPC	Priv.	Illinois Power Co.
		119.0 St.	COEC	Priv.	Commonwealth Edison Co.

(Appendix continued on next page)

Appendix B — Continued

Plant No.	Plant name	Megawatt capacity and type	Utility abbreviations	Type owner	Utilities
27	Dixon	3.2 Hy.	COEC	Priv.	Commonwealth Edison Co.
28	Dresden	208.7 Nu.*	COEC	Priv.	Commonwealth Edison Co.
29	East Alton	9.0 St.	OLMA	Ind.	Olin Mathieson Chemical Co.
31	Fairfield	12.5 St.	FAFI	Mun.	Fairfield
32	Farmer City	1.9 I.C.	FACI	Mun.	Farmer City
33	Fiske	562.2 St.	COEC	Priv.	Commonwealth Edison Co.
35	Fordham	55.0 St.	COEC	Priv.	Commonwealth Edison Co.
36	Freeburg	1.2 Hy.	CEIE	Priv.	Central Ill. Electric and Gas Co.
38	Galesburg	75.3 St.	CEIE	Priv.	Central Ill. Electric and Gas Co.
39	Geneseo	2.6 I.C.	FREE	Mun.	Freeburg
40	Grand Tower	2.6 I.C.	ILPC	Priv.	Illinois Power Co.
41	Granite City	3.5 St.	CEIP	Mun.	Geneseo
42	Granite City	232.6 St.	GRCS	Priv.	Central Ill. Public Service Co.
44	Granite City Steel Co.	15.0 St.	UNSC	Ind.	Granite City Steel Co.
45	Great Lakes Training Station	5.8 St.	GRCS	Ind.	Granite City Steel Co.
46	Harvester	21.0 St.	USN	Fed.	U. S. Navy
47	Havana	.3 I.C.			
48	Hennepin	2.8 St.			
49	Highland				
50	Hutsonville				
52	Jacksonville				
53	Joliet				
56	Joliet Works				
57	Joppa				
59	Lakeside				
60	Liberty Street				
62	Lockport				
63	Marseilles				
64	Marshall				
65	Mascoutah				
66	McLeansboro				

(Appendix continued on next page)

Plant No.	Plant name	Megawatt capacity and type	Utility abbreviations	Type owner	Utilities
67	Meredosia	354.4 St.	CEIP	Priv.	Central Ill. Public Service Co.
69	Moline	3.6 Hy.	IOIG	Priv.	Iowa-Ill. Gas and Electric Co.
		99.1 St.	IOIG	Priv.	Iowa-Ill. Gas and Electric Co.
72	Mt. Carmel	25.5 St.	MOCP	Priv.	The Mt. Carmel Public Utility
73	Murphysboro	2.0 St.	ILEG	Priv.	Illinois Electric and Gas Co.
74	Newton	4.8 St.	NEW T	Mun.	Newton
75	Northwest	173.5 St.	COEC	Priv.	Commonwealth Edison Co.
		50.0 St.	COEC	Priv.	Commonwealth Edison Co.
76	Ottawa	31.9 St.	LIOF	Priv.	Libby-Owens-Ford Glass Co.
77	Peoria	2.8 St.	BEBR	Ind.	Bemis Bros. Bag Co.
78	Peoria	7.0 St.	WAHS	Ind.	Hiram Walker and Sons
79	Peru	15.3 St.	Peru	Mun.	Peru
80	Pittsfield	9.0 I.C.	ILRE	Co-op.	Ill. Rural Electric Co.
81	Powerton	320.0 St.	COEC	Priv.	Commonwealth Edison Co.
82	Princeton	2.8 St.	PRIL	Mun.	Princeton
		5.5 I.C.	PRIL	Mun.	Princeton
83	Rantoul	9.8 I.C.	RANT	Mun.	Rantoul
84	Red Bud	3.2 I.C.	REBU	Mun.	Red Bud
85	Ridgeland	710.0 St.	COEC	Priv.	Commonwealth Edison Co.
86	Robinson	12.0 St.	OHOC	Ind.	Ohio Oil Co.
87	Rochelle	9.7 I.C.	ROCL	Mun.	Rochelle
88	Rockford	6.8 St.	CAJI	Ind.	J. I. Case Co.
89	Rockford	12.5 St.	NALO	Ind.	National Lock Co.
90	Rock Island Arsenal	2.8 Hy.	USAR	Fed.	U. S. Army
		1.0 I.C.	USAR	Fed.	U. S. Army
91	Rockton	1.1 Hy.	SOBW	Priv.	S. Beloit Water, Gas and Electric Co.
92	Wallace, R. S.	325.4 St.	CEIL	Priv.	Central Illinois Light Co.
93	Saybrook	147.0 St.	CEIE	Priv.	Central Ill. Electric and Gas Co.
94	St. David	2.8 St.	LISE	Priv.	Little Sister Electric Corp.
95	St. Louis	15.0 St.	MOCC	Ind.	Monsanto Chemical Co.
97	Savanna	15.5 St.	INPD	Priv.	Interstate Power Co.
99	Sears	1.4 Hy.	SEWP	Ind.	Sears Water Power Co.
100	Southwest	18.0 St.	CHSD	Mun.	Metropolitan Sanitary Dist. of Chicago
101	South Works	105.0 St.	UNSS	Ind.	U. S. Steel Corp.
		38.4 I.C.	UNSS	Ind.	U. S. Steel Corp.
102	Sterling	2.0 St.	NOST	Ind.	Northwestern Steel and Wire Co.
104	Sterling (upper)	2.2 Hy.	COEC	Priv.	Commonwealth Edison Co.

(Appendix concluded on next page)

Appendix B — Concluded

Plant No.	Plant name	Megawatt capacity and type	Utility abbreviations	Type owner	Utilities
105	Stock Yards	1.0 St.	CEMD	Ind.	Central Manufacturing District
106	Sullivan	7.0 I.C.	SULL	Mun.	Sullivan
107	Tuscola	12.5 St.	USIC	Ind.	U.S. Industrial Chemical Corp.
108	Valmeyer	1.3 I.C.	OLMA	Ind.	Olin-Mathiesen Chemical Corp.
109	Vandalia	2.0 I.C.	ILPC	Priv.	Illinois Power Co.
110	Venice No. 1	529.0 St.	UNEC	Priv.	Union Electric Co.
	and No. 2				
111	Vermilion	182.3 St.	ILPC	Priv.	Illinois Power Co.
113	Waterloo	3.0 I.C.	WALO	Mun.	Waterloo
114	Waukegan	752.4 St.	COEC	Priv.	Commonwealth Edison Co.
		325.0 St.*	COEC	Priv.	Commonwealth Edison Co.
115	Will County	670.5 St.	COEC	Priv.	Commonwealth Edison Co.
		510.0 St.*	COEC	Priv.	Commonwealth Edison Co.
116	Winchester	3.2 I.C.	ILRE	Co-op.	Illinois Rural Electric Co.
117	Winnetka	25.5 St.	WINK	Mun.	Winnetka
118	Wood River	262.5 St.	ILPC	Priv.	Illinois Power Co.
		331.0 St.	ILPC	Priv.	Illinois Power Co.
119	Wood River	15.0 St.	STOC	Ind.	Standard Oil Co.
120	Wood River	20.0 St.	SHOC	Mun.	Shell Oil Co., Inc.
121	Woodstock	14.0 St.	COEC	Priv.	Commonwealth Edison Co.
		2.9 I.C.	COEC	Priv.	Commonwealth Edison Co.
122	Edwards, E. D.	136.0 St.	CEIL	Priv.	Central Illinois Light Co.
123	Stonington	1.0 I.C.	STON	Mun.	Stonington
124	Roodhouse	1.5 I.C.	ROOD	Mun.	Roodhouse
125	Bethany	1.4 I.C.	BETY	Mun.	Bethany

25 c. — Indicates frequencies other than 60 cycle

St. — Steam

Nu. — Nuclear

I.C. — Internal combustion

Hy. — Hydro

G.T. — Gas turbine

* — Under construction

Source: Federal Power Commission — Bureau of Power

Map of Principal Electric Facilities — Great Lakes Region" — # 2

1963 — Based on information to June 30, 1962

U. S. Government Printing Office: 1963

Priv. — Private
Co-op. — Cooperative
Mun. — Municipalities
State — State or territory
Fed. — Federal
Ind. — Industrial and privately owned schools

Appendix C

Method of Data Collection

The pulpwood marketing process moves pulpwood from a relatively large number of landowners through pulpwood producers to a smaller number of intermediate agents or "dealers" to pulp and paper manufacturers. One of the objectives of this study was to describe the present pulpwood marketing system in Illinois.

A several-stage enumeration system to cover the marketing and manufacturing stages beginning with mills was used in collecting the data. Because there are only 8 mills which produce pulp and fiber products in Illinois, all of these were completely enumerated. Through these manufacturers, the raw material pulpwood was traced back to its source.

Mills provided the names and addresses of contractors and buyers (dealers), as well as pulpwood producers and landowners from whom they purchased pulpwood in 1961. Only three bonafide dealers were found; all three were interviewed.

Added to the list of landowners were the owner names secured from dealers and producers. Producer and landowner lists were lengthy, thus necessitating the use of sampling procedures. The size of the producer and landowner samples was somewhat limited by the number of man-hours available for field interviewing.

The size of the over-all sample, based on estimated populations, was as follows:

<i>Market agent</i>	<i>Number in the population</i>	<i>Sample size</i>	<i>Sampling intensity, percent</i>
Pulpmills.....	8	8	100
Chipping plants.....	2	2	100
Intermediate agents (dealers).....	3	3	100
Pulpwood producers.....	275 (estimated)	41	14
Landowners.....	300 (estimated)	20	7
Total, all agents.....	588	74	12

The data for the marketing phase were collected through personal interviews; a formal interview schedule was used at each level. In general, the interview schedules provided the information needed to analyze the locations, organization, structure, and general efficiency of the pulpwood marketing system. Supplemental data from many secondary sources were used in the other phases of the study.



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Appendix C

Method of Data Collection

The following method of data collection was used in the study. The data were collected from the records of the Department of Health and Social Services, which are maintained in the form of a computerized database. The data were collected from the records of the Department of Health and Social Services, which are maintained in the form of a computerized database.

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